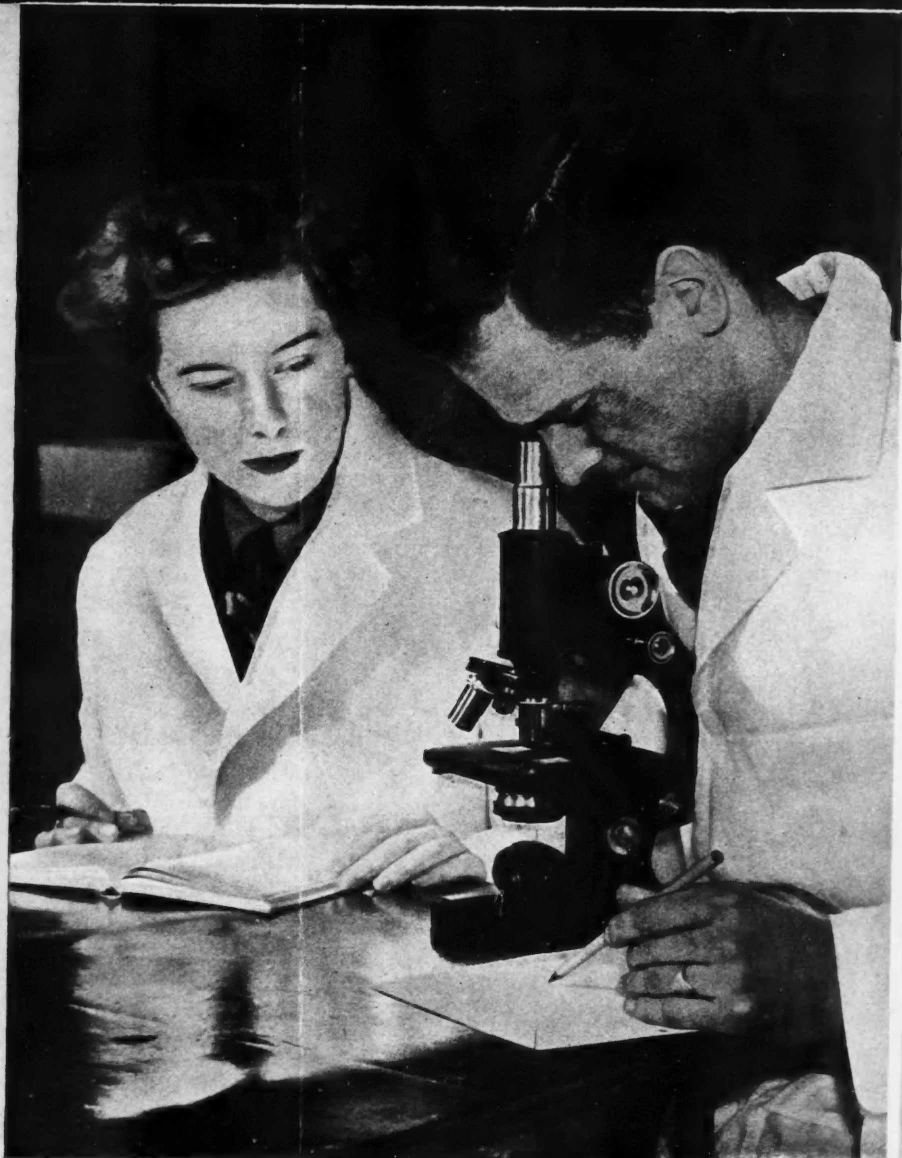
DISCOVERY



PAPER ECONOMY
Reduced in thickness, but not in contents. Approximately 30,000 words in each issue.

JANUARY
1946

1/6

Training

ONE of th
parlous st
the workir
the stage
this link b
stitute the
fundament
reflection
the whole
in technol
our day a
institution
nology an
exceptiona
reverence
Greek mo
of little ac
When w
shortage o
obvious.
technician
start quick
of our un
nology. A
and now
technical e
but as a re
tunate exa
our own h
During t
increased b
Percy com
and impro
universities
problem wh
the chairma
published i
(Stationery
None of
ambit of t

DISCOVERY

THE MAGAZINE OF SCIENTIFIC PROGRESS

January, 1946 Vol. VII No. 1

Editor: WILLIAM E. DICK, B.Sc.
All Editorial communications to
244 HIGH HOLBORN, W.C.1. (Tel. Chancery 6518)
All Subscriptions, Distribution, Advertisements and Business communications to
THE EMPIRE PRESS, NORWICH, ENGLAND. (Tel. Norwich 21441)

The Progress of Science

Training in Technology

ONE of the things which the war brought home was the parlous state of what technologists call "development"—the working up of laboratory processes and techniques to the stage of industrial utility—in Britain. Deficiencies in this link between science and industry were seen to constitute the factor limiting the full application of the fundamental advances made by our scientists, and were a reflection of the state of technological training here. On the whole it is true to say that the fundamental training in technology available was inadequate for the needs of our day and age. The quality of the teaching at such institutions as the Imperial College of Science and Technology and the Manchester College of Technology was exceptional rather than typical. Perhaps because of the reverence in which our educational system still held the Greek mode of life, technology was regarded as a business of little account, fitted only for rude mechanics.

When war came we received an unpleasant shock. The shortage of technicians and technologists became all too obvious. For example, we found that we had insufficient technicians to service the Services' radar sets. We had to start quickly to squeeze a large part of the scientific sides of our universities into the mould of schools of technology. At best this could be only a temporary expedient, and now the time has come to adjust our system of technical education, not in preparation for future wars, but as a result of the lessons of this one and of the unfortunate examples of our past inability to make use of much our own home-produced scientific research.

During the war, the output of trained technicians was increased by 35 per cent in England and Wales, states the Percy committee, and this increase must be maintained and improved upon without diverting the capacity of the universities, which is needed for other things. This is the problem which faced the distinguished committee, under the chairmanship of Lord Eustace Percy, which has now published its report on *Higher Technological Education* (Stationery Office, 6*d*).

None of its recommendations are very drastic, nor is the ambit of the report, which is confined to "Mechanical, Electrical, and Civil Engineering" as wide as might be desired. Its importance lies in the fact that it represents a public acknowledgment by representatives of education and of industry that technological education needs better support. To that extent it will have an effect on public opinion, and may help to balance out the present disabilities under which technical education labours. As things stand, a large proportion of the students at Britain's 150 technical schools and colleges come to their studies tired out after a hard day's work, and, even in the most favourable cases where time off from work is allowed, only a fraction of the student's time is available for study. The building in which the technical college is housed is often old, small, and unsuitable, and there still exist, even in big towns, technical schools that were condemned as insanitary and unsuitable years before the war.

The report is unexciting to read for it is a straightforward demand for more and better buildings, more and better staff, more and better facilities, and more money. On the other hand, pedestrian though this document looks, it has the fundamental pedestrianism that is associated with basic things of life such as food, clothing and the houses without which we cannot hope to add the graces and comforts of an ampler existence.

1951 Exhibition

THE suggestion that a great international exhibition should be held in London in 1951, which originated, to the best of our knowledge, in a letter from John Gloag to *The Times*, has received so much support that we can begin to be hopeful about its eventual materialisation. The suggestion has much to recommend it to scientists, and support for it has already been expressed by members of the Parliamentary and Scientific Committee.

An individual supporter of the idea was Dr. E. F. Armstrong, whose analysis of the effects of the original 1851 Exhibition in a recent presidential address to the Royal Society of Arts on "The Influence of the Prince Consort on Science" has a special interest at the present time. This was the period when countries other than Britain were developing advanced industries. The Exhibition acted not

only as a magnificent demonstration of British industrial strength and therefore as a fine piece of salesmanship, but also as an example which helped to speed up the industrial development of other parts of the world.

For Britain one consequence of the 1851 Exhibition was the focusing of attention upon the need for education. Even at the 1851 Exhibition, when Britain still held a clear lead in most industrial fields, the excellence of workmanship in the wares from some other countries called attention to the need for more systematic manual and technical education in Britain. In response to this need the Department of Science and Art was created in 1853—to promote instruction in drawing, modelling and ornamental art, and to encourage the application of these to manufacture. The further international exhibitions of 1862 and 1867 showed clearly the advantages that Germany and others were drawing from the very extensive systems of technical education they had created. In 1869, for instance, an English writer noted with concern that the tiny state of Württemberg had, besides its polytechnic university, over one hundred trade schools, of which a typical example was the School for the Building Trades, "designed to help . . . lower class builders to be trained for master-builders, constructors of public works, etc. . . . The general workmen whose education it undertakes are plasterers, tilers, roofers, joiners, carpenters, glaziers, turners, decorators, ornament-sculptors, modellers, engravers, smiths, gold and silver workers, gardeners, and husbandmen." He asserted that to obtain the same results England would have to establish 11 endowed technical universities, 11 building trade schools and over a thousand higher trade schools.

The neglect of technical education in England was further emphasised by the Exposition Universelle of 1878, and within two years the Second Royal Commission on Technical Education was appointed "to inquire into the Instruction of the Industrial Classes of certain Foreign Countries in technical and other subjects, for the purpose of comparison with that of the corresponding classes in this country; and into the influence of such Instruction on manufacturing and other Industries at home and abroad". The Commission's excellent recommendations were put into effect during the next ten years with a far greater degree of faithfulness than has usually been the fate of Royal Commission reports. As a result, the foundations were laid by 1890 of our present system of technical education. In spite of its many weaknesses and inadequacies, this has nevertheless gone a long way towards providing the army of skilled workers and lower-grade technicians who are the backbone of modern industrial production.

We have recalled this story at some length because one of the chief benefits that might result from a 1951 Exhibition could be a similar educational development at a new level corresponding to the needs of to-day. Just as technically trained workers became essential to all industry in the second half of last century (and just as scientific workers became essential to some industries), so to-day we have entered on a new phase of industrial development in which the health of the nation necessitates the employment in almost every industry of a high proportion of fully trained scientists—and the full use of their knowledge and skill. The former trend towards an industry based on highly skilled workmen and the present trend towards an industry based on a partnership between those workmen and scientists represent two stages in the industrial revolution of the last two centuries.

There is probably no country in which science could not, with advantage to the whole people, play a bigger part than it does in industry. But we may single out Britain for special attention, partly because Britain is, inevitably, nearest our hearts, but also partly because the need really is more pressing. We have to face a difficult period of reconstruction. Having lost the special privileges of world moneylender that became an important part of Britain's economy after she had lost the special privileges of world exporter, we now have to build up once more our exporting industries. That cannot be done without the fullest use of science. And the woeful fact is that in the past few decades this country has tended to lag in this respect as she lagged earlier in the use of technically trained workmen. British industry uses science, but the scale on which it does so bears the same relation to modern needs as did the Mechanics' Institutes of 1850 to the new needs then arising. British industry's use of science is, in fact, neither very good nor (except in a few black cases like coal and cotton) very bad. But to face the problems of the next few years, a mediocre position is insufficient; we can afford no less than the best industrial use of science.

In the light of all these considerations, if there is one proposal that scientists should lay before those who become responsible for the 1951 Exhibition, it is this: that they should plan the exhibition in such a way as to make clear the tremendous value that science can have for industry. If the exhibition is designed with that among its objects, it should be possible to repeat in regard to science the earlier story of technical education and to start a movement which will in a few years give us the scientific industry that is needed. The planners of the 1951 Exhibition, like their ancestors in 1851, have the opportunity to help mobilise public opinion for the carrying through of very much needed reforms.

One final point needs to be made. The 1951 Exhibition should not stress too exclusively the mere *application* of science to industry. The essence of a strong industrial nation to-day is not so much that it should have a good standard of applied science, but that it should have the highest standard of fundamental science and should apply the results of that fundamental science wholeheartedly to its industry. The exhibition planners should aim to put their emphasis not upon "the application of science to industry", but rather "science—and its application to industry".

Science and Industrial Planning

At the conference on "Scientific Research and Industrial Planning" held by the British Association on December 7 and 8, two outstanding speakers were Dr. C. F. Goodeve, F.R.S. and Professor M. L. E. Oliphant, F.R.S.

Dr. Goodeve's wide experience made him well fitted to expound the subject of "Planning and Organising Research". A brilliant physical chemist, Dr. Goodeve's interests before the war ranged far outside the lecture room and academic laboratory at University College, London, where he was reader in physical chemistry; we find that he helped, for instance, in investigating the scientific problem of minimising atmospheric pollution by the

chimneys of Battersea Power Station. He was an ideal choice as first holder of the post of Deputy Controller of Research and Development at the Admiralty. Recently he left the Navy to take charge of the British Iron and Steel Research Association.

A research organisation, Dr. Goodeve told the British Association, can be efficient only if all its members are thoroughly acquainted with the objectives of the research and conscious of its importance. That is one of the main lessons of war science—the old system in which the requirements of the Services were passed through several hands, only reaching the scientists in a form which hid their real significance and importance, had to give way to one in which the scientists themselves took part in the assessment of requirements from the earliest stages. Scientists studied the problems first-hand, while committees and symposia ensured that this first-hand knowledge was passed directly to their colleagues. The lesson has now to be applied in peace.

The need for collaboration between research organisation and user is now beginning to be recognised. Dr. Goodeve, however, stressed the danger that in certain circumstances the collaboration can be overdone. In particular, near the beginning of a project the inevitable prejudices of the user, arising from his past experience, may lead him to condemn in advance as impracticable a project which is scientifically sound. In general, he suggested, "the user influence should be moderate in the early or research stages and strong in the development stages". One peace-time problem on which war experience can give little help is that user and research organisation are usually in a buyer-seller relation. This leads to difficulties; for example, "it might at a particular moment pay a manufacturer to condemn his supplies of raw materials in order to force their prices down or for the supplier to pass on to the buyer the full cost of a technical improvement". Dr. Goodeve offered no solution, nor did other speakers, who seemed content to quote examples showing that such difficulties do not always arise.

Particularly interesting were Dr. Goodeve's remarks on the relative value of research and development. He quoted the example of a sea mine working by response to the suction caused by ships (see p. 29). Admiralty workers produced such a mine early in the war, but were more concerned with the defence measures to be taken in case it should be used by the enemy. Two programmes were started—one of research to determine all the relevant fundamental information, the other for the development of a sweep which then seemed the most likely solution. The former project cost a few tens of thousands of pounds, the latter some hundreds of thousands. Yet it was the research programme that gave the more useful results. This emphasises the point, made frequently in recent years, that to begin with fundamental research into background information is by far the more economical way of attacking most practical problems.

Professor Oliphant made one of those outspoken statements for which he has become noted, speaking (as he put it) as a pure scientist who has been jolted out of his ivory tower by experiences both before and during the war. He was concerned with the contrast between the long line of geniuses at fundamental research that Britain has produced and the comparatively poor practical use that has been made of their results. (Parenthetically, he noted that the attempt to draw a rigid distinction between "pure" and "applied" research is of recent origin. Although the first duty of a fundamental research worker is in his laboratory, his work does not end there. And, in fact, many of the greatest scientists of the past "were very much mixed up with the economics of their own country and very much concerned with the application of the work that they did.")

He suggested that the basic reason for the failure to apply the results of scientific discovery lies in the financial structure of this country, as compared with that of, for example, the U.S.A. and the U.S.S.R. In Britain there are too many sleeping partners, whose main activity is concerned with attempting to ensure next year's profits by cutting down expenditure on long-term research and development. When a concern runs into financial difficulties, the immediate reaction is to call in, not a scientist or technical man who could tackle the problem fundamentally, but an accountant.

As a result of this "lack of the spirit of adventure in industry" the centre of research and industrial development has been largely transferred to other countries, like Germany and the U.S.A. Too often nowadays production is carried on in Britain merely with the object of circumventing financial and fiscal barriers, the real centre of the industry being the research department of some firm abroad. He regretted the fact that "those who are foremost in urging caution about the future are just those people who are in a position to ensure that caution is exaggerated". Exaggerated caution is far more dangerous than daring that proves occasionally unjustified.

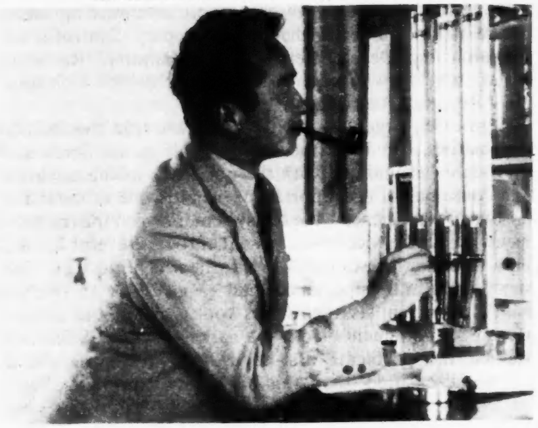
Dealing with the problem of educating applied scientists, Professor Oliphant suggested that our main effort must be to infuse into applied science much more of the adventurous spirit that has guided fundamental research. A future production engineer should not study production engineering at the university. He should study mostly fundamental science, imbibing its spirit and methods; in industry he can learn how to combine the scientific attitude with a knowledge of the practical problems he will encounter. To make this possible will require not merely a revision of university courses, but also a change on the part of industry to the far-sighted attitude of forgoing the possibility of immediate practical results from its recruits in expectation of ultimately far more important developments.

In the discussion, Dr. J. A. Lauwerys drew attention to the fact that the most serious problem the scientific world has to face is the bottleneck in training, not only at the university level, but also in the secondary schools. The present salary scales in schools give the intending schoolmaster little incentive to graduate. With a degree he gets £50 more in salary, but only at a cost of two years' extra training, equivalent to a loss of £600, so that he takes over twelve years to catch up. He pointed out the need for a very great expansion of the universities. Apart from the training of research workers and production scientists, the present need for science masters in secondary schools can be satisfied only by increasing *eightfold* the output of them from the universities, said Dr. Lauwerys.

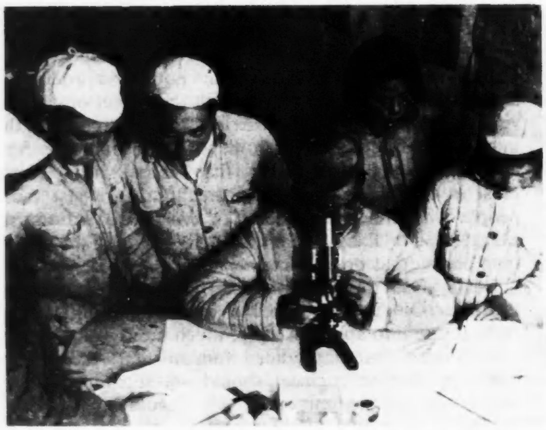
On the conference as a whole one can only comment with regret that it showed little advance on previous years.

China has many scientists studying agricultural problems. Dr. Li Hsien-Wen stands among his new hybrid wheats.

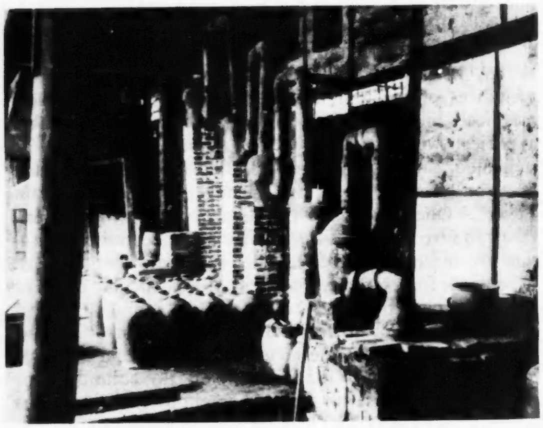
Dr. Tang Pei-Sung, authority on cell respiration, directs Research Institute of General Physiology at Kunming.



More children are learning science. Students studying embryology in the open in the North Shensi Border Region.



Modern technology is developing, but this hydrochloric acid plant is reminiscent of the days of Robert Boyle.



Every city that has a magistrate has its temple to Confucius. Chengtu's is occupied by Yenching University students.

China's scientists have had to put up with makeshift buildings. Dr. Loyang Chi, the neurologist, walks past a typical one.

Dr. Needham's latest book, *Chinese Science*, consists of a dispatch, in pictures with captions, from Chungking, where he directs the British Council's Cultural Scientific Mission. These six pictures are reproduced from it, by permission of the publishers.

DISCOV

There w
objective
practical
It was
the socia
share tow
again and
ing witho
Canadian
iota of c
weaker a
responsib
should ex
considera
but it rem
As it is, th
the impre
and the
that false
that acce
facts and
so.

The Bri

In a worl
an air of
that much
with the
best illust
provided
This off
He had g
"explore t
aid to Ch
exchange
the West"
communic
the wester
scientists
primitive
institution
force, and
bombs ha
since Chi
bartering
price of "
Chinese s
their scient
unimagina
entitled C
price 7s.
aspects of
The Chi
the myriad
compels c
examples.
window-pa
slips were
ciated Sou
of the eva
Nankai, h
but the sup

There was far too much vague discussion of desirable objectives and far too little in the way of proposals for practical action to attain them.

It was particularly deplorable that a conference in which the social responsibilities of scientists to contribute their share towards shaping the future of the world was stressed again and again should end by passing a resolution approving without question or qualification the British-American-Canadian communique on the atomic bomb, without one iota of constructive criticism directed at improving its weaker aspects. If the oft-repeated phrases about social responsibilities mean anything, then it is right that scientists should express their approval of the communique as a considerable advance on the previous state of affairs, but it remains their duty to seek for further improvements. As it is, the British public, through the Press, has been given the impression that no further improvements are possible, and the British Association should take steps to correct that false impression. As one of the few scientific bodies that accepts the responsibility of disseminating scientific facts and opinions among the public it is duty bound to do so.

The British Council and China

In a world of want, "cultural relations" are liable to have an air of pretentiousness about them unless it is realised that much of the work of cultural relations is concerned with the provision of aid of a most material kind. The best illustration within the British Council of this point is provided by the Cultural Scientific Office at Chungking.

This office was opened by Dr. Joseph Needham in 1943. He had gone to China expecting to give lectures and to "explore the possibilities in the cultural sphere of British aid to Chinese institutions and also set in motion the exchange of views between scientists in the East and in the West". By the time he arrived most of the lines of communication between Chinese scientists and those of the western United Nations had been destroyed. Chinese scientists and technologists were working under most primitive conditions. China's scientific and educational institutions had been major targets for the Japanese air force, and much of what escaped destruction by enemy bombs had to be destroyed by the Chinese themselves, since China's military strategy had resolved itself into bartering space for time, a strategy demanding the cruel price of "scorched earth" tactics. The difficulties that Chinese scientists attempting to pick up the threads of their scientific work after evacuation had to face are almost unimaginable to us in Britain, but Dr. Needham's book entitled *Chinese Science* (just published by Pilot Press, price 7*s*. 6*d*.) gives a quite vivid impression of many aspects of those difficulties.

The Chinese scientists were able to surmount a few of the myriad obstacles by an ingenious improvisation that compels our admiration. Dr. Needham quotes several examples. When microscope slides became unobtainable, window-panes broken by air raids were cut up and cover-slips were made from local mica. In the National Associated South-western University, formed by the coalescence of the evacuated universities of Peiping, Tsinghua and Nankai, heating of the laboratories was by electricity, but the supply of element wire for the heaters (home-made out of clay) ran out; work was at a standstill until someone thought of using gun lathe shavings from a nearby arsenal as a substitute for wire. Academic laboratories had to take on work that in the West would have been done in a factory. For instance, the physicists of Peiping Academy helped out their biological and medical colleagues by making microscopes; Dr. Needham stresses that this meant not merely the assembly of parts, but the actual making of the glass, the accurate grinding of the lenses, and the construction of the metal parts. In this respect the Chinese scientists were forced back to conditions such as we associate with the times of Boyle, Hooke and Leeuwenhoek. In chemical technology we find Chinese chemists having to carry out not only research but also the task of developing an industrial application based on their research all the way through pilot-plant stage to actual production. (In the years to come the appreciation that they are thus gaining of practical problems should prove very valuable, for there can now be little ignorance among Chinese scientists of the importance of development work.)

But no matter how resourceful the Chinese were, many of their immediate material needs went unsatisfied. They lacked many of the tools of the scientific trade. Much of the work of Dr. Needham's unit has therefore been concerned with meeting some of their most urgent needs. For example, with a credit arranged by the Cultural Scientific Office, China has been enabled to buy chemicals and apparatus from India; some 60 university departments and other institutions have benefited thereby. Last year some 2,500 books, procured in response to special requests from Chinese scientists, were received and distributed from the office in Chungking. Every month many scientific and technical periodicals (including Discovery) are flown to China in micro-film form. These are a few of the ways in which the Cultural Scientific Office has helped China. After reading Dr. Needham's book one can see that there is no pretentiousness about the Chungking office.

In 1940 an apocryphal story was told of the British Council sending out a colourful description of the dresses at Ascot when certain common men in dirty, blood-stained battledress were fighting for the ideals of Western civilisation in a practical way that all foreigners could understand, including those who remain unmoved by fashion parades at race meetings. Dunkirk swept away many of our dangerous illusions, not least among which were certain widely held illusions about cultural propaganda. The British Council is now working along lines that the common people can approve. The more it develops and expands such work as it has done in China the greater the support and the less the criticism it may expect from the British public.

Silicones

The engineer lives a life of continual compromise with his materials. A material of maximum hardness may be low in tensile strength; one of great tensile strength may be comparatively soft—and he must choose a compromise to suit his problem and then adapt his design to the limitations of the material chosen. Engineering advances very often depend on the development of new materials combining properties which in previously available materials were

The way in which silicones withstand heat is illustrated in this photograph. These Diesel exhaust stacks were painted at the same time, one with silicone-base paint, the other with ordinary paint that has burnt away.

mutually exclusive. The most recent addition to the materials at the engineer's disposal is the whole class of *silicones*. It is to be understood that the plural word covers a whole family of substances, to which new additions may be expected with each month that passes. The members of that family are chemically similar, but differ in physical properties. Silicones are giving the engineer a wide variety of new combinations of properties to work with.

The electrical engineer has been the first to benefit from the industrial development of silicones. In many kinds of electrical equipment the insulating materials available limit the temperature at which the equipment can be run; the temperature must be kept down, otherwise the insulating materials decompose and insulation fails. In a composite insulator in which is incorporated a varnish on top of inorganic materials such as glass, asbestos or mica, the varnish is ordinarily the weak point. Substitution of a silicone varnish that is heat-resistant for the conventional varnish eliminates that weakness. Already, by taking advantage of the higher running temperatures possible with silicone insulation, engineers of the Westinghouse Electric Corporation of America have been able to reduce the size of a 10 h.p. motor by 50 per cent, obtaining as much power from the half-size motor that runs at 175° C. as from a full size motor running at 105° C.

Silicones are but one family of compounds belonging to the branch of chemistry called by the lucid but unlovely name of organo-silicon chemistry. Silicon lies near carbon in the periodic table and, as one would expect, silicon can be substituted for carbon in many organic compounds. It was in the course of systematic work in the field of organo-silicon chemistry that the English chemist, F. S. Kipping (then a newly appointed professor at University College, Nottingham) stumbled upon the silicones. As Professor Kipping recently told a reporter many of the products of his syntheses were "sticky, gummy messes which were a nuisance", but he duly recorded their occurrence in his research papers, where they remained as mere laboratory curiosities for about thirty years. It was not until the mid-1930's that the sticky, gummy character of the silicones was recognised as a portent of potential industrial usefulness. The management of the most important glass firm in America, Corning, was disturbed at the prospect of competition from the transparent plastics. Was it possible to develop new materials from the point where plastics chemistry grazed glass chemistry; would it be possible to develop substances as easy to handle as plastics, but with some of the heat resistance of glass? Those were the sort of questions which led to the exploration of organo-silicon chemistry by industry. Corning Glass Works, taking a broad view of their problem, commissioned Dr. J. F. Hyde to undertake fundamental research. He, with his team, chose to follow up Kipping's work and the eventual outcome was a new branch of chemical industry, in which the silicones are one but not the only item.

In silicone manufacture, the raw materials are sand, brine, coal and oil. (To say that is not to overlook the intricacy of the technology involved, any more than if one says aniline dyes are made from coal tar.) The sand, together with chlorine from the brine, eventually yields silicon tetrachloride; from coal and oil and more chlorine come organic chlorides. Link these together, by means of the well-known Grignard reaction, and organo-silicon chlorides are produced. Hydrolysis followed by condensation of the units formed on hydrolysis, produces the silicones.

The key to the course of commercial development lay largely in the availability of cheap magnesium needed for the Grignard reaction. Dow Chemical Company had perfected a process for producing magnesium at a low cost and this firm now joined forces with the Corning Glass Works to form, in February 1943, the Dow-Corning Corporation for the development and production of silicones. So far Dow-Corning is the only firm in the world with a plant in operation, but the American G.E.C. (which is linked to Westinghouse, mentioned earlier) is erecting a second plant. Silicones are now being investigated in Britain, and it is to be hoped that manufacture will soon follow.

Already silicones have been developed for uses other than in electrical insulation. Other silicones provide lubricating greases which will work in temperatures from −40° C. to 200° C. without freezing at one end or melting at the other. With these greases an aeroplane could fly without lubrication trouble from the pole to the tropics.

Certain of the liquid silicones adhere firmly to the surfaces of ceramic or glass insulators and render them strongly water-repellent. This property proved of great value during the war, particularly in the radio apparatus of aeroplanes. A somewhat similar treatment may be used to make paper or textiles water-repellent.

An official of G.E.C. opened a Press conference in 1944 by emptying a packet of cigarettes into a bowl of water and then offering them to the startled reporters. They had been waterproofed by a silicone treatment and remained in excellent condition.

One of the most curious of the silicones—one which has no practical use as yet—has been christened "bouncing putty". If a lump of it is dropped, it bounces like rubber; if squeezed, it deforms like putty. If left alone, it settles like pitch.

Sir Robert Robinson

PRESIDENT OF THE ROYAL SOCIETY

It is a symptom of the high degree of specialisation which is characteristic of modern civilisation that a scientist can enjoy so great an international reputation as Sir Robert Robinson, the newly elected president of the Royal Society, and yet remain virtually unknown to the general public. (To justify that last remark I quote from my own experience. Recently I had occasion to consult the "cuttings" library of an important London newspaper. In Sir Robert's envelope there were just two cuttings; the first was a report of his speech to the Parliamentary and Scientific Committee in which he advocated control of German nitrogen fixation plants as one strand that would give strength to post-war security; the other cutting described his skill as an explosives chemist—a quite clear case of mistaken identity, since all the facts it contained seemed better to fit Sir Robert *Robertson*!)

I do not wish to convey the impression that Sir Robert has specialised narrowly in one small sector of chemistry. He has indeed nothing in common with the German dyestuffs chemist who told Lord Moulton, "I only deal with methyl blues"—surely the *reductio ad absurdum* of scientific specialisation. Sir Robert has worked out many widely different problems in organic chemistry.

He is regarded as one of the greatest organic chemists alive to-day. As a chemical paper expressed it: *Willstätter in his prime was the leader and foremost contributor to the advancement of organic chemistry, stepping as it were into the shoes of Emil Fischer. To-day the torch of progress is grasped by Sir Robert Robinson.* If one can ignore the metaphorical cocktail, one recognises this as a fair statement of Sir Robert's pre-eminent position.

The Manchester School of Chemistry

Born in Chesterfield on September 13, 1886 (his father was a pioneer in the manufacture of surgical dressings, who devised and put into use several new machines including the first lint machine and who also introduced cotton dressings), he was educated at Fulneck School and Manchester University. The fame of Manchester as a centre of chemical teaching in those days far exceeded that of either Oxford or Cambridge. Roscoe and Schorlemmer had laid the foundations of the chemistry department and when Robinson became a student there it was at the height of its fame, with H. B. Dixon and W. H. Perkin (Sir William Perkin's eldest son) as professors of inorganic and organic chemistry respectively, and J. F. Thorpe, W. A. Bone, D. L. Chapman and Dr. Chaim Weizmann in subordinate positions. Young men from all over Britain were attracted to the department, and among Robinson's fellow-students were W. N. Haworth, J. L. Simonsen, R. E. Slade, E. W. Smith, J. H. Andrews and V. J. Harding (who later became professor at Toronto).

By the time he was 26, Robinson had secured a professorship of his own, at the University of Sydney. Before he left to take up the Australian appointment he married Miss Gertrude M. Walsh, whom he met while a student at Manchester. She also studied chemistry there, and took her M.Sc.

Between 1912 and 1930, when he succeeded W. H. Perkin as Waynflete Professor of Chemistry at Oxford, he occupied chairs of organic chemistry at Liverpool (1915-1920), St. Andrews (1921), Manchester (1922-28) and University College (1928-30). The only break in the academic sequence occurred in 1920 when he was for a short time research director of the British Dyestuffs Corporation.

Before attempting a very brief résumé of his most outstanding work I should first mention his contribution to the development of theoretical organic chemistry. Without a theoretical plan to guide one the chance of success in the field of organic synthesis would be of the "needle in a haystack" variety. His classic synthesis of tropinone (a base closely related to atropine and cocaine) whereby the straight chains of his starting materials, succindialdehyde, acetone and methylamine, were gathered up into the ring structure of the alkaloid was not based on guesswork. Shortly before he attempted that synthesis he had worked out a theory to explain how plants might build up chemical products. It was that theory which inspired him to proceed to the tropinone synthesis. Fifteen years later it was proved that the particular sequence of reactions that went to Robinson's tropinone synthesis did actually occur in the living plant! Electronic theory has provided many clues to the solution of the complex problems of chemical reactivity met with in organic chemistry. There is no room here to detail the ideas that Robinson has put forward and that have done much towards collating masses of otherwise unrelated chemical facts. Readers may care to have a reference to two of Robinson's lectures on the subject, published by the Royal Institute of Chemistry under the title "Outline of an Electrochemical (Electronic) Theory of the Course of Organic Reactions."

Synthesis of Flower Pigments

From the alkaloids (his researches included work on morphine and he also established the structural formulae of strychnine and brucine), he turned to a study of the pigments that give flowers their remarkable range of colours—the *anthocyanins* (the blue-red colouring matters) and the *anthoxanthins* (the yellow pigments). Willstätter and his co-workers had established that anthocyanins were in the nature of glycosides (that is, substances based

on sugars, which are produced when the glycosides are decomposed). Moreover, it was known that they had an amphoteric nature, being capable of forming salts on treatment with acids *or* alkalies. For example, the violet pigment common to cornflowers, roses and dahlias can be isolated; treated with hydrochloric acid it forms a *red* hydrochloride, whereas with caustic soda a *blue* sodium salt is formed. From the hydrochloride can be derived a base called cyanidin. (Hydrolytic splitting of the hydrochloride yields cyanidin chloride and glucose; the cyanidin chloride has itself a deep violet colour.) Three other bases resembling cyanidin are to be found widely distributed among flowering plants; there are pelargonidin, delphinidin and malvidin, deriving their names respectively from the scarlet "geranium", the larkspur and the mallow. Out of these substances, and rather rarer ones called hirsutidin (occurring in certain primulae), peonidin and petunidin, flowers synthesise the whole range of colour shades and tints which outvie the rainbow.

All of the anthocyanidins were synthesised by Robinson and his team. The synthetic pigments proved identical with those occurring naturally. Sir Henry Dale remarked, when presenting Sir Robert with the highest award of the Royal Society, the Copley Medal, in 1942, that this formed "one of the most brilliant achievements in the whole range of modern organic chemistry".

This work on anthocyanins is of wide interest. It is now possible by small-scale tests to find out what anthocyanidins are present in a particular flower to give it a particular hue. (A catalogue of many flower colours was published by Sir Robert and his wife in *The Biochemical Journal* and the *Philosophical Transactions*.) Flower colour had been studied on the one hand by geneticists and on the other by the organic chemists; combining the two approaches it was possible to study inheritance of flower colour from a chemical point of view, and this was done just before the war by a team including Dr. Beale, Sir Robert and Lady Robinson, Miss R. Scott-Moncrieff, Dr. J. R. Price and Mr. W. J. C. Lawrence.

This pioneer study of the chemico-genetics of flower colour was made in collaboration with John Innes Horticultural Institution and the beautiful results that were obtained can be seen, illustrated in full colour, in the *Journal of Genetics* for 1939. In plant physiology anthocyanins may have functions but these have yet to be elucidated; the plant ecologist, too, has an interest for he would like an explanation, for instance, for the fact that saltmarsh plants such as seablite are more highly charged with anthocyanin the nearer they grow to the sea. (A physiological explanation of the blaze of anthocyanins seen in autumn leaves is also required.)

Synthetic Hormones

Of recent years an entirely different group of chemicals came within Robinson's ambit—the hormones called oestrogens. In this work Robinson collaborated with Professor E. C. Dodds and the outcome was the synthesis of three substances—stilboestrol, hexoestrol and dienoestrol—which are chemically not identical with any natural hormone but which are physiologically more active than the oestrogens so far discovered.

They are also active when given by the mouth, whereas the natural ones are then inactive except in large doses. Cheap to produce, they have already found much use in medicine. Stilboestrol has been found capable of inducing artificial lactation in virgin goats and other animals, opening up a potential field of application in farming. Of great promise, too, is the use of stilboestrol to treat cancer of the prostate (see DISCOVERY, January 1944, p. 32).

Research on Penicillin

During the war Sir Robert has been closely connected with investigations into the constitution of penicillin, which was isolated in Sir Howard Florey's laboratories situated next door to the Dyson Perrins Laboratory, of which Sir Robert is director. He was almost an automatic choice for chairman over the Medical Research Council committee set up to correlate work on penicillin synthesis.

Although Sir Robert is practically unknown to the public, he has served them well through his membership of various Government committees. It would take too much space to mention all the committees on which he has served, but the names of a few of those with which he has been associated during the war may help to indicate the extent of this side of his work. On the Scientific Advisory Council of the Ministry of Supply he has served two terms. He was a member of that Ministry's committee which looked into the possibility of making synthetic rubber in Britain. He has been a member of the Chemical Board, and chairman of the Chemical Sub-Committee of the Chemical Defence Research Department ever since the 1914-18 war.

During the last war he visited the U.S.A. three times as a member of Government missions.

The Colonial Office makes use of his knowledge on the Colonial Products Research Council. His wide experience of the chemical profession came into play in connection with the recruitment of chemists through the Central Register, and he presided over the committee of chemists advising the Register. He was a member of the Treasury committee that recommended modification of the Hydrocarbon Oil Duties. He has seen five years' service on the Advisory Council of the D.S.I.R. and has presided over the Chemical Research Board and the Water Pollution Research Board.

Many honours have come his way including the highest that the Royal Society and the Chemical Society can award. Of the latter body he has been president. As a vice-president of the Royal Society, he led the recent delegation of British Scientists to Moscow. WILLIAM E. DICK

INDUSTRIAL development, the provision of sufficient houses, and the improvement of our transport system will inevitably mean more encroachment upon the British countryside. But inseparable from the recognition of Britain's needs in these directions is the intensified determination that rural beauty shall not be unnecessarily sacrificed and that our flora and fauna shall be preserved. That determination is not the ideal of a few, but of the majority; however, the essential preliminary planning that is necessary before effect can be given to that determination has up to now been the concern of a few. The ordinary person, preoccupied with the tasks of total war, has not had the opportunity even to read about what the planners have been doing. For example, the Nature Reserves Investigation Committee, set up in 1942 to study one aspect of the problem, has secured next to no publicity. Yet before plans for nature reserves can stand any chance of being implemented public opinion must be informed about them, and it was for that reason we asked the committee's secretary, Dr. Herbert Smith, to describe its work.

The Nature Reserves Investigation Committee

ITS GENESIS AND OBJECTS

G. F. HERBERT SMITH, D.Sc.

THE story of the Nature Reserves Investigation Committee may be traced back to the year 1929. On September 26 of that year the National Park Committee, under the chairmanship of Dr. Christopher (now Viscount) Addison, was appointed by the Rt. Hon. Ramsay MacDonald, then Prime Minister. It happened that in 1924 the British Correlating Committee had been set up to co-ordinate the activities of the constituent societies upon all matters of common interest dealing with the protection of animal and plant life, the promotion of nature reserves, and kindred objects. The membership comprised one representative nominated by each of the following bodies: Trustees of the British Museum, the British Ornithologists' Union, the (now Royal) Entomological Society of London, the Gilbert White Fellowship, the British Section of the International Committee for Bird Preservation, the Linnean Society, the National Trust, the Royal Society for the Protection of Birds, the Society for the Preservation of the Fauna of the Empire, the Society for the Promotion of Nature Reserves, and the Zoological Society of London. The writer was appointed honorary secretary-treasurer.

The Committee was invited to give evidence before the Government committee, and accordingly met on November 1, 1929, to agree upon it; Sir Peter Chalmers Mitchell was nominated principal witness, with Prof. E. J. Salisbury and the writer in support. In order to widen the consideration of the subject a representative of the British Ecological Society, the Director of the Royal Botanic Gardens, Kew (Sir Arthur Hill), and the Keeper of Botany of the Natural History Museum (Dr. A. B. Rendle) were co-opted to the Committee, and the Geological Society of London was consulted. The witnesses appeared before the Government Committee on December 4, and the evidence is printed as an appendix in the Report.* It includes a schedule of areas which should be preserved, the group—mammals, birds, insects, plants, or geology—for which they are of interest being indicated.

* H.M. Stationery Office, Cmd. 3851 (1931).

Altogether 66 localities were given—54 in England, 5 in Wales, and 7 in Scotland. A further list of areas of special geological interest was added by the Geological Society.

Owing to the economic difficulties which developed in that and subsequent years the Government took no action upon the report, and only now, after a lapse of fourteen years, does a move towards the establishment of National Parks seem probable. As there appeared to be no need for the continued existence of the British Correlating Committee they disbanded in 1936. In that same year the Council for the Preservation of Rural England, together with the corresponding Council for Wales, established the Standing Committee on National Parks to revive interest in the subject as regards England and Wales. The writer was nominated by the Society for the Promotion of Nature Reserves to serve on it as representative of the former British Correlating Committee. Except for an unavoidable period of dormancy at the outbreak of war the Standing Committee has been steadily active. It may be remarked

Barton Broad, listed by the Nature Reserves Investigation Committee under proposed national nature reserves, has been acquired by the Norfolk Naturalists' Trust. 500 acres in extent, it has a very rich fauna.

The Committee proposals include 47 national reserves, 25 conservation areas and 3 national parks. Ecological associations as well as individual species would be protected if the scheme was adopted. In the map, *R* stands for Reserve, *C* for Conservation Areas. The suffixed letters *A, B, C*, indicate the order of importance attached to particular reserves and conservation areas, *A* being the highest category.

that it is concerned with National Parks from every aspect, and the preservation of plant and animal species is not in the forefront of their programme.

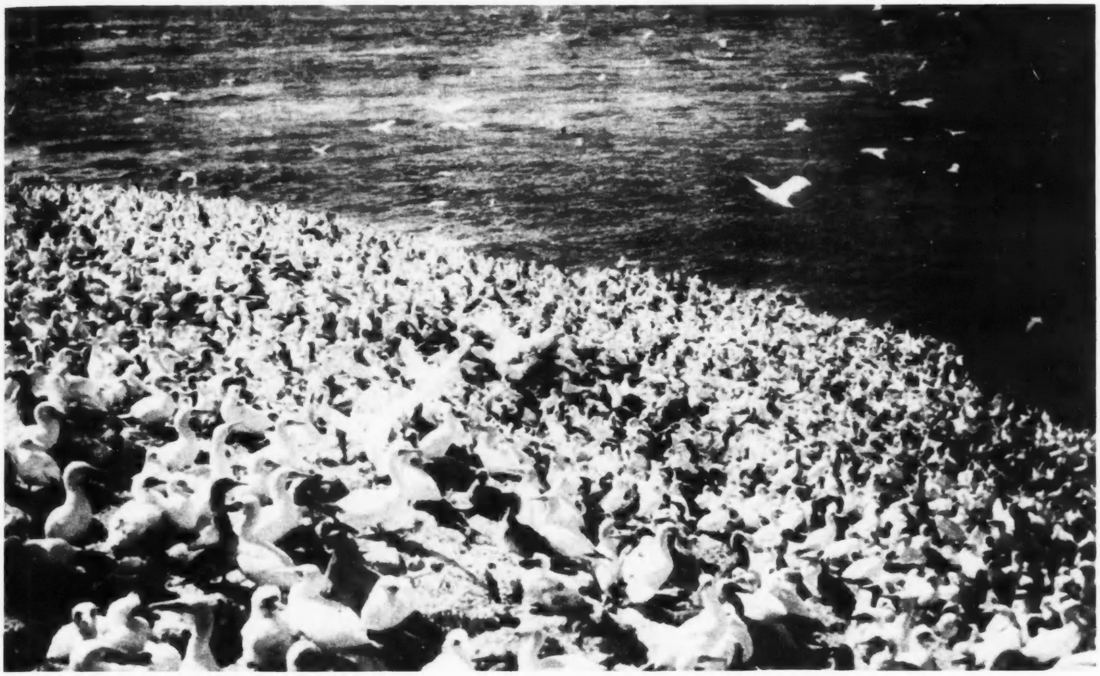
In January 1941, with the appointment by Lord Reith, then Minister of Works and Buildings, of an expert Committee on Compensation and Betterment, the importance of safeguarding the natural history of the country in any national policy for the use of the land began to exercise the minds of various naturalists despite the anxious times through which the country was passing. Eventually the writer was led to communicate to the late Earl of Onslow, the President of the Society for the Promotion of Nature Reserves, the suggestion that it would be advisable to convene a conference of representatives of societies interested in the preservation of plants and animals to consider whether and what steps should be taken to secure the end in view. After some deliberation Lord Onslow agreed to the proposal, and suggested that invitations to nominate delegates should be addressed not only to societies but to local government associations as well.

With the additions which were subsequently made, 20 organisations* were represented on the Conference for the Preservation of Nature in Post-War Reconstruction.

The inaugural meeting was held at the House of Lords on June 5, 1941. As a basis of discussion the delegates had before them a memorandum, which had been prepared by Mr. Dent, on a proposed post-war policy for the provision of bird sanctuaries. In it he pointed out that the selection of areas should correspond to their ecology, and that different types of country should be included, and he emphasised that the Government should accept the principle that it was their duty to preserve some portion of what is left of the flora and fauna of the country. In the course of the discussion it was remarked that in the present state of public opinion the preservation of forms of life would come second to the preservation of fine scenery, and the importance of working in harmony with the existing Standing Committee on National Parks was brought out. Finally the delegates appointed a Drafting Committee, consisting of Mr. W. L. Platts (chairman), Sir Lawrence Chubb, Mr. G. Dent, Sir Peter Chalmers Mitchell, Dr. E. J. Salisbury, and the writer as honorary secretary (Capt. C. Diver and Dr. J. Ramsbotton were subsequently added) to prepare a memorandum on general principles.

At the second meeting in July 1941 the delegates had before them the memorandum, couched in the form of a letter to the Prime Minister, and discussed at considerable length the administration of National Parks. In the draft it had been suggested that this should be entrusted to County Councils, in conjunction in appropriate cases

* The British Association for the Advancement of Science (Dr. Julian S. Huxley, Prof. E. J. Salisbury), British Ecological Society (Capt. C. Diver, Mr. C. S. Elton), British Museum (Natural History) (Dr. C. Forster-Cooper), British Ornithologists' Union (Dr. G. Carmichael Low, Mr. N. B. Kinnear), British Trust for Ornithology (Dr. A. Landsborough Thomson, Mr. James Fisher), Council for the Preservation of Rural England (Sir Lawrence Chubb, Dr. G. F. Herbert Smith), Council for the Preservation of Rural Wales (Sir Lawrence Chubb), County Councils Association (Mr. W. L. Platts), Geological Society of London (Prof. H. L. Hawkins, Dr. R. W. Pocock), Home Office (Wild Birds Advisory Committee) (Lord Onslow, Mr. A. J. Adams), International Committee for Bird Preservation (British Section) (Miss P. Barclay-Smith, Mr. D. Seth-Smith), Linnean Society of London (Mr. I. H. Burkill, Dr. Malcolm A. Smith), The National Trust (Mr. N. B. Kinnear, Mr. D. M. Matheson), Royal Entomological Society of London (Mr. J. C. F. Fryer, Mr. H. M. Edelsten), Royal Society for the Protection of Birds (Mr. G. Dent, Mr. R. Preston Donaldson), Society for the Preservation of the Fauna of the Empire (Mr. H. G. Maurice, Sir Peter Chalmers Mitchell), Society for the Promotion of Nature Reserves (Dr. J. Ramsbottom, Mr. N. D. Riley), Urban District Councils Association (Mr. D. J. Jones, Mr. E. C. King), and Zoological Society of London (Sir Francis Lindley, Dr. Julian S. Huxley). Lord Onslow was elected chairman of the Conference and the writer honorary secretary. The Association for the Preservation of Rural Scotland, the National Trust for Scotland, and the Zoological Society of Scotland expressed themselves as in general sympathy with the objects of the Conference, but because of transport difficulties were unable to send delegates. The Association of the Municipal Corporations was represented until February 1943.



The Pembrokeshire coast (from Penrhyn Castle to Tenby) forms a proposed conservation area. Included in it should be the islands, such as Skokholm, Skomer, Grassholm and Ramsey. The photograph shows a gannet colony on Grassholm; seals are also abundant there. (*Photograph by H. L. Gregory; by courtesy of the Royal Society for the Protection of Birds.*)

with County Borough Councils; but it was pointed out that this proposal was at variance with the recommendation of the National Park Committee—that it should be placed in the hands of a National Authority—which was strongly supported by the Standing Committee on National Parks. Finally the document was referred back to the Drafting Committee for revision in the light of the discussion and for consultation with the Standing Committee on National Parks.

The document in its final form was considered by the Conference at the third meeting in October, and subject to a few minor alterations was approved. It was published under the title *Memorandum on the Provision of National Parks and the Preservation of the Fauna and Flora in Great Britain* in November. (A second edition appeared in September 1942.)

Government Receives a Deputation

In January 1942 a joint deputation from the Conference and the Standing Committee on National Parks was received by Lord Reith, then Minister of Works and Buildings, who was accompanied by Sir Geoffrey Wiskard, Mr. H. G. Vincent, and Mr. G. L. Pepler. The Conference was represented by Lord Onslow, Mr. Platts, and the writer, and the Standing Committee on National Parks by Sir Norman Birkett, Prof. (now Sir) Patrick Abercrombie, and the Rev. H. H. Symonds. Sympathetic consideration was given to the views expressed, and it was arranged that the details should be informally examined in the first instance by Prof. Abercrombie, Mr. Platts, Mr. Symonds, Mr. Vincent, and Mr. Pepler, but, as Lord Reith soon afterwards went out of office, no meeting was held.

The next step was that Sir William (now Lord) Jowitt, who had been appointed Minister without Portfolio to act as Chairman of the Ministerial Committee concerned with problems of reconstruction after the war, received a deputation from the Conference on May 4, 1942, in order to discuss the Memorandum. After general consideration of it and cognate matters he invited the Conference to appoint an appropriate Committee to advise the Government on matters relating to nature reserves. The Conference thereupon met on June 24 under the chairmanship of Lord Macmillan, in succession to Lord Onslow, who had been compelled by ill-health to retire from office, and appointed the Nature Reserves Investigation Committee, as it was termed, with the following membership: Sir Lawrence Chubb, Mr. G. Dent, Capt. C. Diver, Mr. J. C. F. Fryer, Mr. N. B. Kinnear, Prof. W. H. Pearsall, Dr. J. Ramsbottom, Prof. James Richie, Dr. E. J. Salisbury, the writer, and Mr. W. L. Taylor, the last named being added at a later date. Their terms of reference were as follows:

1. The object of the Committee is to examine proposals for the establishment of nature reserves as part of the general scheme of national planning; and to obtain information from such bodies or persons as may be directly or indirectly concerned with the formation, organisation, or administration of nature reserves or sanctuaries.

The Peak District, the Lake District and Snowdonia are proposed as national parks. Here is Dovedale, with the Castle Rocks on the left; this region, owned by the National Trust, is important as it contains unspoilt primitive ashwood. The Peak District has great ecological interest for its sub-alpine flora, and fine examples of cotton grass, bilberry and heather moors. (*Photograph by "The Times"*.)

2. The Committee shall have a quorum of two, have power to refer any part of their inquiry to one or more of their number, and may arrange with any other person to carry out on their behalf specific investigations and report thereon.

3. In particular, the Committee shall inquire into and report upon to the Conference:

(*a*) The types and approximate areas of reserves and sanctuaries which should be provided to ensure the preservation of communities or species.

(*b*) The species of plants and animals which are in danger unless special arrangements are made to secure their preservation and reproduction.

(*c*) The localities or sites where such reserves and sanctuaries should be situate.

(*d*) The extent to, and conditions under, which the public should have access to the various reserves.

(*e*) Such other arrangements as are necessary to ensure the proper preservation of the county's flora and fauna.

(*f*) The most appropriate methods for acquiring, controlling, and administering the reserves.

(*g*) The methods of financing the provision and maintenance of the reserves and other necessary expenditure.

At the same meeting it was resolved that: "This Conference authorises the Investigation Committee to afford advice to Government Departments on any specific aspects of the matters involved, on which they may be consulted or consider it desirable to tender advice." It will be noticed that the functions of the new Committee were not unlike those of the defunct British Correlating Committee, and the writer was honorary secretary of both Committees.

At the inaugural meeting in July 1942, the Committee elected Sir Lawrence Chubb chairman and the writer honorary secretary. The scope and character of the Committee's work were discussed at some length, and it was decided to collect the fullest possible information about existing and potential nature reserves, in addition to those already listed by the Society for the Promotion of Nature Reserves. At the second meeting, in September 1942, a memorandum by Mr. Dent on the classification of nature reserves was considered, and learning that the Ministry of Works and Planning was about to delimit four potential National Park areas, namely the Lake District, Peak District, Dartmoor, and Snowdonia, and had asked for information about tracts or sites in or near them of special natural history interest, the Committee decided to establish local committees to advise them on these points.

At the third meeting, in October 1942, Dr. E. C. Willatts, of the Ministry of Works and Planning, was present, in order to furnish the Committee with whatever additional information might be required. He explained that the Ministry had taken over planning powers, and was working in close liaison with the Ministry of Health and the Ministry of Agriculture, and added that the Committee's views on general principles and lists of recommended nature reserves, together with suggestions for their acquisition, conservation, and management, would be welcome. It was reported that the four local committees required had been formed and had already got to work. The Committee authorised the establishment of additional local committees so as to cover the whole of England and Wales, this being the only sure way to accomplish their task satisfactorily and expeditiously.

At the fourth meeting, in December 1942, the establishment of the Scottish Nature Reserves Committee with

he writer
he Com-
d it was
on about
to those
f Nature
1942, a
of nature
Ministry
potential
ct, Peak
sked for
of special
establish

. E. C.
ng, was
whatever
xplained
ers, and
f Health
he Com-
f recom-
for their
uld be
mmittees
o work.
ditional
and and
sh their

tablish-
ee with

(*Above*) Snowdonia is one of three national parks recommended by the Committee and in the Dower report. The photograph shows Llyn Gwynant. (*Below*) Chesil Bank comes within the portion of the Dorsetshire coast from Portland to Sidmouth that forms a proposed conservation area. In this picture Portland Bill and Weymouth can be seen in the distance. Bushes of seablite (*Suaeda*) fringe the inner side of the shingle beach which ranks as the finest in England.

Prof. James Ritchie as chairman and Mr. T. H. Gillespie as secretary was reported; their wish to work in close co-operation with the London Committee was considered to be guaranteed by the fact that Prof. Ritchie was a member of both committees. The general scheme of regional committees for England and Wales, which had been drawn up, was approved in principle, and the memorandum on principles was further considered and referred to the Drafting Committee for final revision. The memorandum was considered again at the fifth meeting, in January 1943, and was remitted to the Conference. It met in February, and after making a few minor amendments approved of the publication of this report on *Nature Conservation in Great Britain* as Memorandum No. 3, published in March 1943. (A second edition appeared a few months ago.)

During 1943 a comprehensive system of regional committees was established covering England and Wales. Each of the following areas has its Regional Committee: (1) Northumberland, Durham; (2) Cumberland, Westmorland, Lancashire north of the Ribble; (3) Yorkshire; (4) Lincolnshire; (5) Nottinghamshire, Derbyshire; (6) Lancashire south of the Ribble, Cheshire; (7) Wales, Monmouthshire; (8) Staffordshire, Shropshire, Warwickshire, Worcestershire, Herefordshire; (9) Leicestershire, Rutland; (10) Northamptonshire, Bedfordshire; (11) Norfolk; (12) Suffolk; (13) Cambridgeshire, Huntingdonshire, Essex; (14) London, Middlesex (extending also to a radius of 20 miles from St. Paul's into Hertfordshire, Essex, Kent and Surrey); (15) Hertfordshire, Buckinghamshire; (16) Oxfordshire, Berkshire; (17) Kent, Surrey, Sussex; (18) Hampshire, Isle of Wight; (19) Dorset; (20) Gloucestershire, Somerset, Wiltshire; (21) Devon; (22) Cornwall.

So far as possible the formation of the regional committees was entrusted to local societies, universities or museums, but in certain instances where, largely owing to war conditions, this course proved impracticable individuals who were known to be interested, were asked to form committees.

The seventh meeting extending over the period from April 1944 to September 1945 was devoted almost entirely to the consideration of the regional reports and the preparation of a report on *National Nature Reserves and Conservation Areas in England and Wales*. A special Sub-Committee was set up to deal with the geological features, Dr. Herbert Smith being the chairman. The other members were Dr. S. E. Hollingworth, Dr. G. H. Mitchell, Dr. K. P. Oakley, and Mr. T. H. Whitehead, nominated by the Director of the Geological Survey of Great Britain, and Dr. David Williams, nominated by the Geological Society of London; Dr. Oakley was the honorary secretary. Their report on "National Geological Reserves in England and Wales" was published as Memorandum No. 5 in September 1945 and was mentioned in the following month's DISCOVERY.

It should be emphasised that the whole of this elaborate machinery of the Central Committee and Regional Committees remains in full operation and is available for consultation by Government Departments and Local Authorities. The whole of the expenses involved have been met from a grant made by the Pilgrim Trust, and no charge has fallen on public funds, and the services of all those concerned with the enterprise have been freely given.

Considerable interest has been taken in the Committee's reports by South Africa, Canada, and the United States of America. The United States National Park Service appeared to have been so impressed with the report on *Nature Conservation in Great Britain* that a few months ago they prepared a synopsis for circulation to their fieldmen and to some of the leaders in American conservation work, and prefaced it with the following tribute:

"Imagine Great Britain in March 1943, with bombs still dropping sporadically on London and environs, the country pushed to the utmost in manpower and domestic economy; and no certainty, whatever the hope, that it can survive the impact of war; and yet these sturdy, unpanicked people initiate and go ahead with plans for the amenities of future Britons; for the protection of natural resources; for the preservation of plant and animal species with relation to their habitat, etc., etc. What imagination is this, which sees that, if Britain is worth dying for, these things are worth dying for, because they are intrinsic to the enjoyment of freedom itself! And they feel that future generations would not forgive them if they preserved the husk, after letting the kernel be destroyed. Surely there is a lesson here for us, who encounter not one per cent of the difficulties in the way of Britain."

SINCE the above article was written, the Nature Reserves Investigation Committee has published its report entitled *National Nature Reserves and Conservation Areas in England and Wales*. This costs 3*s*. and may be obtained from The Society for the Promotion of Nature Reserves, British Museum (Natural History), London, S.W.7.

The map on p. 10, reproduced from this report, shows the location of the 47 national nature reserves and 25 conservation areas listed in the document. These represent the minimum requirements of any national scheme of nature preservation, and they are here described in such a way as to make the report a most valuable gazetteer to areas most interesting to naturalists and ecologists.

The Committee has kept its proposals well within the bounds of practicability, having cut its recommendations to the minimum with that aim in mind. The 25 conservation areas, for instance, defined in the report embrace no more than 1530 square miles—an area little bigger than that of, say, Kent or Cumberland. The total area of national reserves does not amount to a five-hundredth of the area of England and Wales—equal to a rectangle of less than 10 by 12 miles.

Both nature reserves and conservation areas have been most stringently selected purely on their scientific merits. The Committee reviewed the whole of England and Wales irrespective of whether any of the sites recommended might be included within the boundaries of some future National Park, but the important part that the creation of National Parks might play in the securing of nature preservation is recognised and three districts—the Lake District, the Peak District and Snowdonia—are considered in the report, which expresses the opinion that "the only satisfactory solution would seem to be that they should be preserved as National Parks."

We are returning to the view of the Greek philosophers and the alchemists that elements are qualities and not constituents.
Every one of the conceptions which associated the atom with the chemical element now has to be modified.

FREDERICK SODDY

ISOTOPES

B. A. LISTER, M.Sc., A.R.C.S., A.R.I.C.

FOR the past two thousand years, scientists and philosophers have had before them the problem of attempting to explain the nature of matter. During this time many and varied theories have been put forward, but it is only relatively recently that fact has crept up upon and ousted philosophy as the basis for these theories.

The idea that all matter was composed of minute particles has been in the minds of thinking men since the earliest recorded times, but it was not until the beginning of the nineteenth century that the atomic theory was given a precise form which admitted of quantitative verification. In 1804, Dalton put forward the hypothesis:

(1) that matter was composed of small, indestructible particles which he called atoms;
(2) that all the atoms of any single chemical element were identical in all respects;
(3) that atoms of different elements possessed different properties; and
(4) that compounds were formed by the union of atoms of different elements in simple numerical proportions.

Although the basis of this theory has remained unshaken up to the present time, some revision of its postulates has been necessary in the light of discoveries of the last thirty or forty years. No longer can all the atoms of a chemical element be considered to be identical, nor can we say that all the atoms of different elements must necessarily possess completely different properties.

The first inkling of the existence of what are now known as isotopes came from a study of the radioactive elements. Since many of the radio-elements could only be procured in unweighable amounts, the problem arose of how to obtain a knowledge of their chemical nature. However, by adding a known element to a solution containing a minute quantity of the radio-element, precipitating and finding whether the activity resided in the precipitate or the filtrate, it was possible to discover the element most closely resembling the unknown element. With many of the radio-elements it was found that the resemblance to a known element was so great that, after mixing the two, it was impossible to separate them again, the mixture behaving as a single chemical entity. Radiothorium, for example, could not be separated from thorium; nor mesothorium from radium. To explain this phenomenon, the then novel assumption was made that the atoms of the radio-element and of the inactive element had the same chemical properties but differed from one another in atomic weight and radio-active behaviour. Thus the radio-element was not a new element at all but merely a particular form of a known element and, from the chemical point of view, belonged to the same place in the periodic classification. For this reason, Frederick Soddy, one of the great men whose names will always be associated with this work, called it an *isotope* (*isos* equal, *topos* place) of the more common element.

In 1914, Rutherford, speaking at Sydney, said, "There may be two pieces of lead which look exactly the same and yet their physical qualities may be quite different." This prophesy has been well and truly fulfilled, for to-day we know that there are at least seven elements which may properly be called lead, but they all have different atomic weights. Ordinary commercial lead has been aptly described as a "mongrel" of many isotopes.

Simultaneously the phenomenon of isotopy was discovered in the field of the inactive elements through the work in this country of Sir J. J. Thomson.

Towards the end of the last century it was discovered that if atoms are subjected to a strong electric field at low pressure, they tend to ionise, that is, to split up into particles, some of them positively charged, some negatively charged; in the simplest case of ionisation two particles are produced. One particle is invariably the electron carrying one unit of negative charge and the other particle, which carries an equal and opposite charge, is obviously dependent on the atom ionised. The influence of the electric field causes these particles to move with high velocities in opposite directions, the stream of electrons becoming a cathode ray and the stream of positively charged particles being known as a "positive ray".

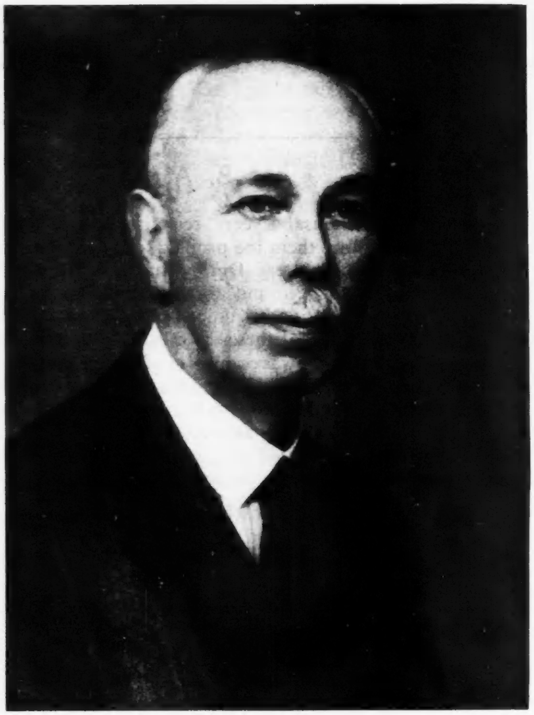
The analysis of these positive rays was first carried out by Sir J. J. Thomson using the apparatus shown in Fig. 3. The amount of deviation of the positive rays, using fields of constant strength, varies directly with the value of e/mv (e=charge, m=mass and v= velocity of the particles), and so for particles of a single species, when the only variable is the velocity, their locus of impact on the photographic plate is a parabola.

For particles of two species, e.g. those of different mass or charge, two parabolas are apparent, and so on.

During an examination by this method of the more volatile constituents of air, Sir J. J. Thomson found, in in addition to the parabolas of the known gases, one

THE atomic bomb project involved the large-scale separation of uranium isotopes, and the whole subject of isotopy has thereby gained great topical interest. This article outlines the ideas that led up to the isotope hypothesis and the experimental work which established the existence of isotopes, dealing in particular with the work of J. J. Thomson and Aston and the development of the mass spectrograph. The second half of the article, to appear in February, will cover various methods of separating specific isotopes, including the electromagnetic method, gaseous diffusion, thermal diffusion, distillation, centrifuging and chemical exchange. It will also describe the preparation of artificial radioactive isotopes and their important uses in biological and medical research.

Sir J. J. Thomson (1856–1940).



Dr. F. W. Aston (1877–1945).

corresponding to an atomic weight of 22. After a great deal of careful and laborious work planned with the purpose of separating this new constituent, the parabola was shown to arise from the presence of a second species of neon atom and we were thus given the first demonstration that a stable chemical element (as distinct from radioactive elements) could exist as more than one form or isotope.

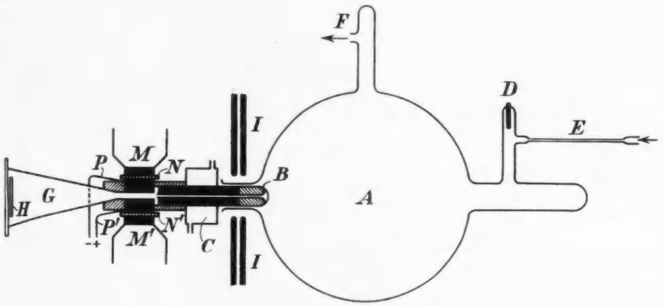
As we have already seen, from the earliest times the hypothesis has periodically been put forward that all matter is composed of one primordial substance, but one of the first definite theories on these lines was suggested in 1815 by William Prout, the London physician who made chemical research his hobby. Prout held the view that the atoms of the elements were merely different aggregations of atoms of hydrogen. On this view, obviously, all the atomic weights should be expressed as whole numbers, but as the accuracy of atomic weight determinations increased the theory was condemned as "an illusion, a mere speculation definitely contradicted by experience".

More recently, however, through the work of Sir J. J. Thomson and others, the "primordial substance" hypothesis was given fresh birth and the theory was adopted that the atoms of elements are themselves built up of the "atoms" of positive and negative electricity, protons and electrons. During the last ten or fifteen years the list of sub-atomic particles discovered has rapidly grown, the neutron, positron, meson and neutrino having in turn been hailed as newcomers in the atomic treasure hunt, a game which has become increasingly popular among chemists, physicists and mathematicians.

For an explanation of the general properties of isotopes, however, the atom can be considered as being built up of three constituents, the electron, proton and neutron, the last-named having the mass of a proton, but carrying no electrical charge. The nucleus is composed of protons and neutrons only, these particles contributing nearly the whole of the atomic mass, and all the electrons may be considered as being outside the nucleus, their configuration determining the chemical properties of the element.

So it is to the nucleus that we must turn for our explanation of the existence of isotopes. Obviously, if the electrical neutrality of the atom is to be maintained, the number of positive charges (or protons) in the nucleus must be the same in each of the isotopes, and the observed differences in atomic mass must be explained by a difference in the number of neutrons. In fact, isotopes may be colloquially described (here I am again quoting Soddy) as "elements, the atoms of which have similar outsides but different insides".

Figs. 5(*a*) and 5(*b*) illustrate diagrammatically the atomic structure of two of the isotopes of potassium (the + symbol represents a proton and *n* a neutron). The nucleus of the isotope of mass 39 contains 19 protons and 20 neutrons, this positive charge being balanced by 19 electrons outside the nucleus. The 40 isotope has the same electron configuration, but an extra neutron in the nucleus increases its mass by one unit. If now we add to the 39 isotope of potassium an electron and a proton, we obtain the structure shown in Fig. 5(*c*). This atom, an isotope of calcium, has a different electron



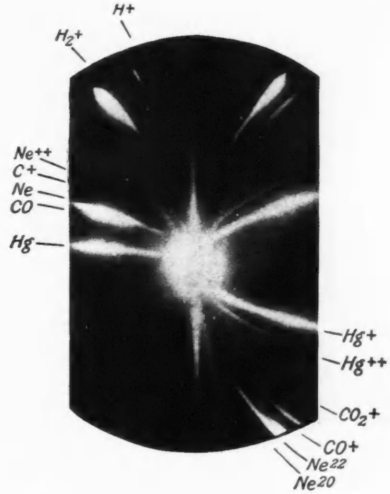


FIG. 3 (*above*).—J. J. Thomson's positive ray apparatus. The beam of positive rays formed in the bulb *A* strikes the cathode *B*, some of the rays passing through a narrow channel drilled in the cathode to be analysed on the far side by electric and magnetic fields. The electric field is so arranged that it causes a vertical deflection of the positive rays and the magnetic field so that a horizontal deflection is obtained, the beam finally passing on to impinge on a fluorescent screen or a photographic plate, *H*. FIG. 4 (*right*).—The parabolas of neon (Ne 20, Ne 22).

configuration but the same nuclear mass as the 40 isotope of potassium. Such atoms possessing similar masses, but different chemical properties, are known as "isobars". Although this term is not encountered as frequently as the term "isotope", the phenomenon of isobary is quite common, and in a number of cases we find an isotope of each of three elements possessing the same atomic mass —the three isotopes are then known as isobaric triplets.

If two atoms vary in any way they may be classified, according to a scheme proposed by Soddy, into four groups, as shown in the table.

Type	*Atomic Weights*	*Atomic Numbers*	*Examples*
Heterobaric heterotopes	Different	Different	Lithium and chlorine
Heterobaric isotopes	Different	Same	Thorium and ionium
Isobaric heterotopes	Same	Different	Mesothorium-2 and radiothorium
Isobaric isotopes	Same	Same	Radium D and radium- Ω"

The final class—isobaric isotopes—is of special interest, for although the pair of atoms possess identical mass and atomic number they show different radioactive behaviour.

It is clear that the number of positive charges on the nucleus (the atomic number) is of far greater importance in determining the properties of an element than the atomic weight, the latter being merely a statistical mean value of the weights of the different isotopes. This revolution in chemical knowledge led Soddy to remark that "there is something, surely, akin to if not transcending tragedy in the fate that has overtaken the life work of that distinguished galaxy of nineteenth century chemists, rightly revered by their contemporaries as representing the crown and perfection of accurate scientific measurement. Their hard won results, for the moment at least, appear as of little interest and significance as the determination of the average weight of a collection of bottles, some of them full and some of them more or less empty." The situation, however, is not as black as that rather bitter comment would lead one to believe for, from the point of view of chemical analysis, the chemical atomic weight is just as important as ever.

The parabola method of analysis described earlier, although very useful for the general survey of masses and velocities, has many objections as a precision method. As a result, an instrument was developed by F. W. Aston at Cambridge which overcame many of these objections and permitted measurements of a higher degree of accuracy to be made. (Figs. 6, 7.)

The principle of this instrument, the mass spectrograph, is illustrated in Fig. 8. The positive rays, which are formed by the same means as in the parabola apparatus, after arriving at the cathode face, pass through two very narrow parallel slits and the resulting thin ribbon of rays is spread out into an electrical spectrum by means of two oppositely charged parallel plates. A group of these rays is selected by a diaphragm and is caused to pass between the poles of a powerful electromagnet, the magnetic field deflecting the rays in the opposite direction to the electric field. As we saw when considering the parabola method of analysis, the magnetic deflection varies directly with $\frac{e}{mv}$ and, by balancing the action of the electric field with that of a certain magnetic field, it is possible to focus on one strip of the photographic plate all particles selected by the slits and having the same value for $\frac{e}{m}$. Furthermore,

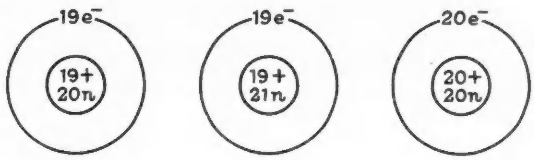
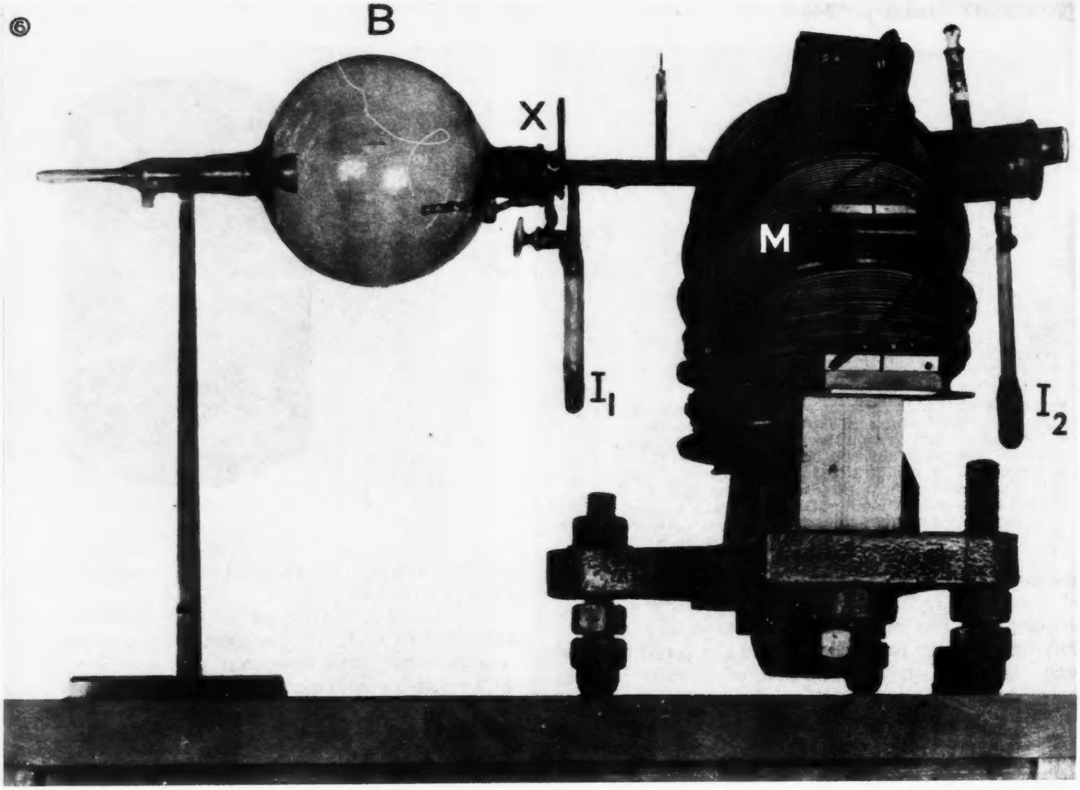
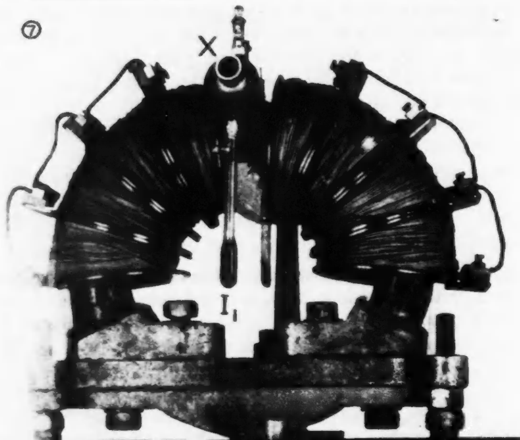


FIG. 5.—DIAGRAMMATIC REPRESENTATION OF ISOTOPES AND ISOBARS

(*a*) 39 isotope of potassium.
(*b*) 40 isotope of potassium.
(*c*) 40 isotope of calcium.
(*a*) and (*b*) are isotopes. (*b*) and (*c*) are isobars.





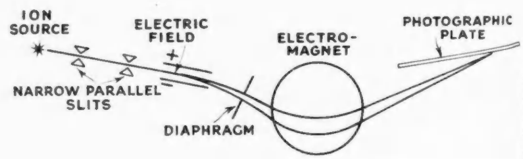


FIG. 6.—Aston's original mass spectrograph which he set up in the Cavendish Laboratory in 1919; now in the Science Museum. *B*, discharge tube; I_1, I_2, charcoal/liquid air tubes exhausting slit system and camera; *M*, electromagnet. FIG. 7.—A better view of the electromagnet. FIG. 8.—Principle of Aston's mass spectrograph.

the position of the plate can be adjusted so that the foci of streams of particles with different values of $\frac{e}{m}$ will all lie on the surface of the film and so give sharp impressions. Thus the image obtained on the plate is similar to an optical spectrum, each line indicating the presence of particles of a fixed value of $\frac{e}{m}$.

It may be helpful towards the understanding of the instrument if we draw an analogy between the mass spectrograph and an optical spectograph. If the heterogeneous beam of positive rays is supposed to be one of white light, then the electric and magnetic fields are glass prisms deflecting the light in opposite directions, the slit system acting as a collimator. But whereas in the optical instrument the prisms are fixed, with the mass spectrograph we can alter the refraction at will by controlling the electric and magnetic fields.

In 1925 an improved instrument was set up in the Cavendish Laboratory at Cambridge having five times the resolving power of the original one and an accuracy of about 1 in 10,000. During the following decade many models of the mass spectrograph were designed and valuable results were obtained. The introduction of new sources of positive rays increased the usefulness of the

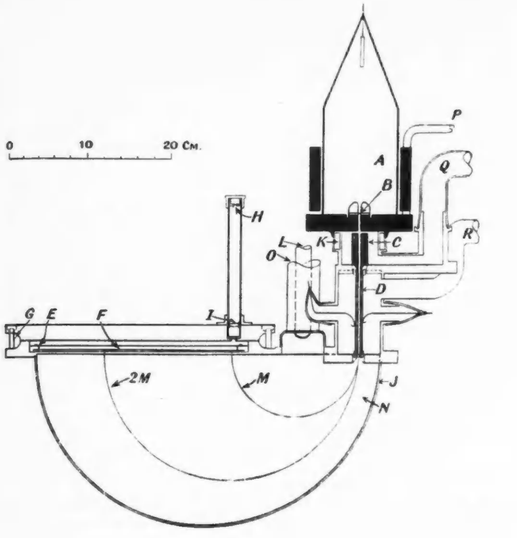


FIG. 9.—Bainbridge's mass spectrograph.

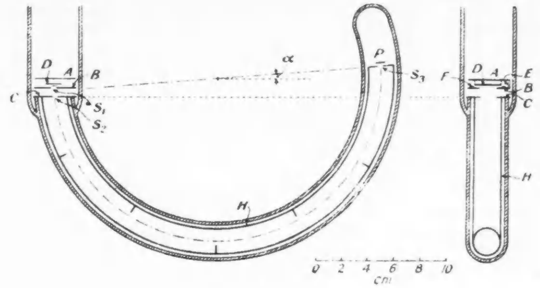


FIG. 10.—Nier's mass spectrometer.

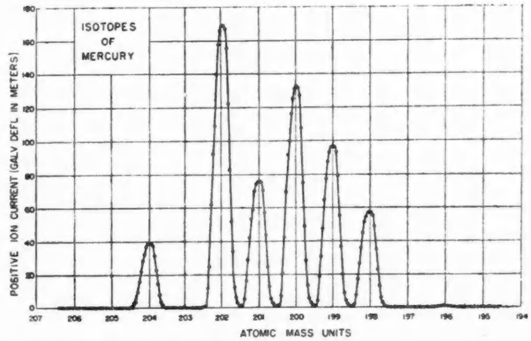


FIG. 11.—Curves for isotopes of mercury (from Nier spectrometer).

instrument, its scope being extended to include the study not only of the elements which may be introduced as vapours or vapourisable compounds, but also those whose compounds are less volatile. Two of these new sources may be briefly mentioned: the first was an externally heated anode consisting of a platinum strip coated with a salt of the metal under investigation, and the second a "composite anode", a mixed paste of graphite and a metallic salt which was automatically heated by the discharge itself.

In Bainbridge's mass spectrograph (1930–5), which made use of the hot anode principle as a source of positive rays, the ions were accelerated by means of a high potential difference thus producing a homogeneous beam of mass rays—homogeneous, that is, with regard to velocity and not, as in earlier instruments, with regard to energy. These accelerated rays were subjected to semicircular focusing by means of a very large electromagnet designed to give a uniform field up to 15,000 gauss over a semicircular area 40 centimetres in diameter. A diagram of Bainbridge's mass spectrograph is shown in Fig. 9.

The term "mass spectrography" is often loosely applied to any method of positive ray analysis but, strictly, it should be reserved for work with an apparatus capable of producing a focused mass spectrum of lines on a photographic plate. An instrument which, on the other hand, detects and measures beams of mass rays brought successively on to a fixed slit should be termed a mass spectrometer, the study being known as mass spectrometry. A typical mass spectrometer which is of general application is that due to Nier (Fig. 10). The rays formed by direct ionisation of the vapour of the element concerned, or of one of its compounds, are accelerated by suitable applied voltages and are deflected through a semicircular path by a large electromagnet. Passing through a narrow slit, they are collected on a plate and the ion current is measured by a valve amplifying device.

The procedure in an analysis consists of plotting the ion current over the range of accelerating voltages and a typical curve, that of the isotopes of mercury, is shown in Fig. 11. With the Nier type mass spectrometer, abundances as low as 1 in 100,000 can be measured.

From the time of Aston's first experiments, the power of the mass spectrograph has increased enormously until in an instrument designed by Jordan (1940) the accuracy has reached 1 part per million and the mean dispersion 14·6 mm. for 1 per cent difference of mass.

Recently the mass spectrometer has found considerable use in chemical analysis, its most important application being in the field of oil analysis; it is possible to deduce the composition of a complex mixture of hydrocarbons in a short time, an accuracy of better than 5 per cent being claimed.

It is impossible in an article of this length to consider in detail the great amount of important information which has been collected from the study of mass rays, but a few interesting examples might be quoted.

The first and perhaps most important generalisation which could be made from the results obtained with the mass spectrograph was that the weights of all atoms could be expressed, to a high degree of accuracy, as whole numbers. When more precise determinations were made, however, it was found that there was, in fact, a very small but measurable divergence from this "whole number rule". From a curve connecting the deviations, or *packing fractions* as they are called, with the mass number, we can predict in a general way the changes in mass, and hence

[Continued at bottom of next page

Night Sky in February

M. DAVIDSON, D.Sc.

The Moon.—New moon occurs on February 2d. 04h. 43m., U.T., and full moon on February 16d. 04h. 28m. The following conjunctions take place:

February			
13d. 03h.	Mars in conjunction with the moon	Mars	3° N.
13d. 09h.	Saturn ,,	Saturn	2 S.
20d. 20h.	Jupiter ,,	Jupiter	3 S.

The Planets.—Mercury is in superior conjunction with the sun on February 11 and is not well placed for observation except towards the end of the month when the planet sets about 1¼ hours after the sun. Venus is in superior conjunction with the sun on February 1 and is not very favourably placed for observation during the month. On February 28 the planet sets about 25 minutes after the sun and can be seen for a short period in the western sky. Mars, in the constellation of Gemini, can be observed throughout the night. During the month the distance of Mars from the earth varies between 64 and 81 million miles. The planet is stationary on February 22d. Jupiter, in the constellation of Virgo, rises at 23h. 47m., 22h. 56m., and 22h. at the beginning, middle and end of the month respectively, and is stationary on February 11. The distance of the planet from the earth varies between 477 and 541 million miles from February 1 to 28. Saturn, in the constellation of Gemini, can be seen throughout most of the night, setting at 6h. 41m. and 4h. 50m. at the beginning and end of the month respectively. During this time Saturn's distance from the earth varies between 756 and 781 million miles.

Times of rising and setting of the sun and moon are given below, the latitude of Greenwich being assumed:

February	Sunrise	Sunset
1	7h. 40m.	16h. 48m.
14	7h. 18m.	17h. 12m.
28	6h. 49m.	17h. 37m.

February	Moonrise	Moonset
1	7h. 40m.	15h. 48m.
14	15h. 00m.	6h. 47m.
28	5h. 34m.	13h. 28m.

The constellation of Cassiopeia contains many interesting objects, among which may be noticed the region surrounding the star γ which has a companion magnitude 9 at a distance of over 7 minutes of arc. Unfortunately ordinary binoculars will not render the companion visible but on a clear night it can be seen with a 3-inch telescope or even with a smaller instrument. There are about a dozen very faint stars close to γ but they can be seen only with a large telescope. η Cassiopeia is a yellowish star with a companion of purple colour at a distance of about 5 seconds of arc. Cassiopeia is famous because in 1572 a very brilliant temporary star or nova appeared near κ and had a profound effect on Tycho Brahe who observed it very carefully. It received the name of "Tycho's Star", not because he discovered it, but because he gave such careful attention to studying its light variations. The effect of this star on the defenders of the philosophy of Aristotle was far reaching, and the actual words of Tycho in this connection are worth quoting, showing, as they do, how reactionary were the ideas of Aristotle and how his influence on Europe delayed scientific progress:

"All philosophers agree that in the ethereal region of the celestial world no change either in the way of generation or corruption takes place; but the heavens and the celestial bodies in the heavens are without increase or diminution, and that they undergo no alteration either in number or in size or in light or in any other respect; that they always remain the same, like unto themselves in all respects, no years wearing them away."

Tycho expressed the opinion that it was a star shining in the firmament which had never been seen before in any age since the beginning of the world, and the above quotation shows the thraldom in which men of science were held by Aristotle's philosophy.

ISOTOPES—*continued from previous page*

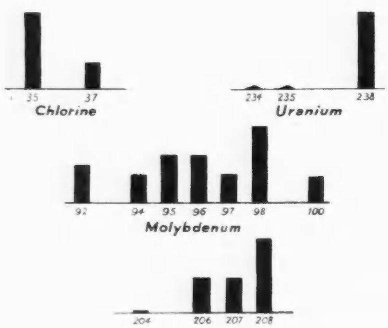


FIG. 12.—Relative abundances of the isotopes of chlorine, uranium, molybdenum and lead. Uranium metal, for example, contains 0.7% of U235 as against 99.3% and 0.006% of U238 and U234.

in energy, to be expected from transmutations of nuclei. A discussion on isotopes is not the place to dwell on the subject of nuclear fission, but emphasis should perhaps be laid on the importance of the determination of packing fractions to work on atomic energy.

By 1941, all the elements had been analysed by the mass spectrograph and, now that the picture is more or less complete, certain statistical relations become obvious. For example, the number of neutrons in the nucleus—a number which, incidentally, tends to be even—is at least equal to, and usually greater than, the number of protons; the lightest isotope of hydrogen is an exception to this rule. Further, the number of isotopes of an element and their range of mass numbers seem to have definite limits, the elements of odd atomic number never having more than two isotopes. Odd mass numbers are much rarer than even ones, only one element, tin, having more than two odd-numbered isotopes. Some of these facts are illustrated in Fig. 12, which gives an idea of the relative abundance of the isotopes of a few elements.

(Figs. 3, 4, 9, 10 and 11 are taken from Aston's *Mass Spectra and Isotopes*, by courtesy of the publishers, Edward Arnold & Co.)

(To be concluded)

[Continued from p. 373

Mines and Counter-Measures

By Lieutenant-Commander, S. J. BROOKFIELD, R.N.V.R.

THE enemy took the initiative early in the mining campaign of this war; we were to some extent forced to allow this because, being so dependent on sea communications, the introduction of new mining methods was not always in our interests. After an impressive battle of wits between rival technicians we overtook and later outstripped him. But our interest in the new firing systems and sweeps which were developed in the course of this technical battle should not allow the exotic nature of the innovations to obscure the value of the immense amount of seamanship, human endeavour and risk that was contributed by the men in ships laying and sweeping the familiar buoyant contact-type mines.

These were used in great defensive fields as well as for offensive purposes. A mine of this type is generally laid from the stern rails of a surface minelaying vessel,* although some may be released from submarines. The method of depth taking by a plummet attached to the sinker is fairly well known, but in mines released from submarines a hydrostat is incorporated in the mine for depth-taking. In the hydrostat method the mine reaches the sea-bed still resting on its sinker (Fig. 20), which contains the carefully "reeled" steel cable for mooring, and also a number of ingenious devices.

A clock in the sinker can keep the whole assembly dormant on the sea-bed for a period up to several weeks if required. When the clock reaches the end of its run it automatically closes an electric circuit which fires a cutter. This severs the rope by which the mine is secured to the sinker, the mine is released and the mooring cable begins to run out as the mine floats upwards. When the mine reaches a predetermined depth below the surface the operation of its hydrostat releases a loose bight of cable, causing momentary slackening of the mooring rope. A mechanism in the sinker reacts and locks the drum. By this means mines will take up a final position just below the surface when laid in water down to many hundreds of feet in depth; special mines and thinner cable are needed for greater depths. In addition to being fired by the contact of a vessel with one of its horns, a mine may have its radius of action extended by a floating snagline attached to one of the horns as in Fig. 20, so that it will fire when a vessel fouls the snagline. The explosive charge is generally about 500 lbs.

The tension in the mooring cable of the mine pulls on a lever which keeps a switch in a "live" position, so that in the event of the mine breaking adrift the switch returns to its safe position. In the case of mines washed ashore, firing is sometimes due to this lever, or a length of cable still attached to it, catching on rocks, etc. This safety device, required by International Law, is superior to the corresponding German device which is susceptible to interference by barnacle growths. During the violent storms of October 1945, out of 157 British mines washed up on the south coast of England only 12 fired.

* Every mine laid from surface vessels contains a soluble plug which keeps a safety switch open in the firing circuit until it dissolves after the layer is well clear.

Oropesa Sweep

During the 1914-18 war ships gained considerable immunity from contact mines by a self-protection device consisting of a cable from the bows to a paravane on each bow. The paravanes were not unlike a V1 flying bomb in shape, and were set with a steering mechanism to give the cable a good spread away from the towing vessel. They have also been used in this war but their usefulness is limited against many of the new types of mines. Buoyant mines are now swept mainly by Oropesa sweeps (Fig. 22) the development of which began in 1918 with trials in a trawler, H.M.S. *Oropesa*. These consist essentially of a winch, "kite", kite wire, sweeping wire, "otter" and float. The kite and otter differ only in the method of slinging; each is a square metal frame with transverse inclined planing surfaces. The kite is

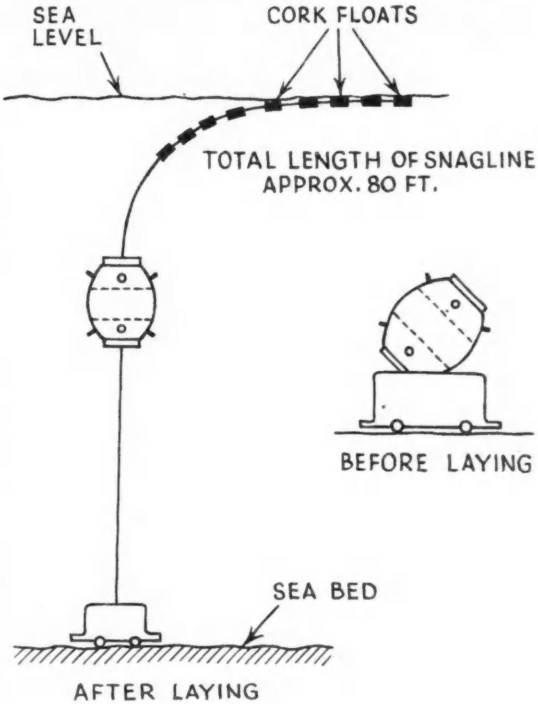


FIG. 20.—Buoyant mine (snagline type) and sinker.

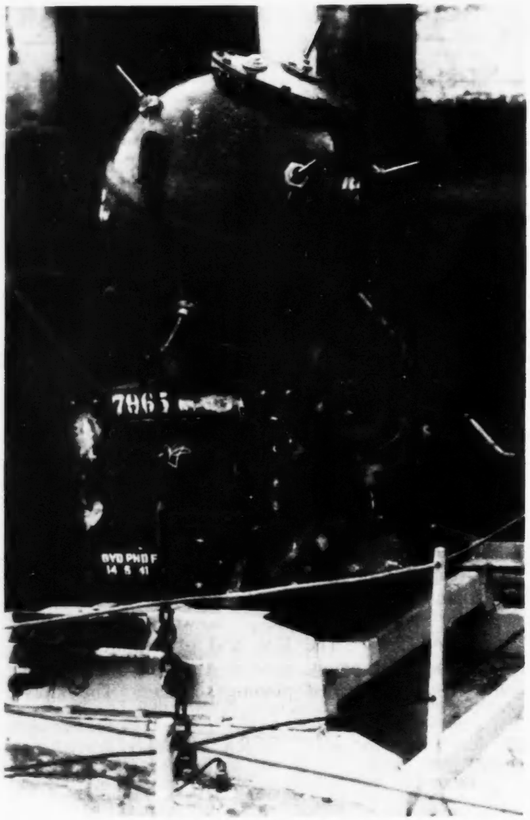


FIG. 21.—Buoyant mine (plummet type).

slung so that these surfaces are horizontal, and the otter so that they are nearly vertical. At the inboard end, the sweep wire is snatched to the kite which is towed by the kite wire. The kite performs two functions; firstly it takes the sweep down to the required depth, and secondly it keeps the inboard end of the sweep in the track of the minesweeper. Thus it eliminates the danger of an unswept band of water close to the ship. The otter is supported at the desired depth by the Oropesa float (Fig. 24) and is slung to steer away from the minesweeper, and to give spread to the sweep. Due to the action of the water passing through its planes it leads the sweep out on to the quarter of the towing ship. Both otters and kites require calibrating before use. The sweeping wire is made of serrated hard steel so that the mooring cable of a mine will be severed when the sweep wire is pulled across it. Sometimes the sweep is armed at intervals with static or explosive cutters: it can then deal even with the chain cable used to moor some mines and with anti-sweep devices (one of these devices, an Obstructor Unit for cutting the sweep, is shown in

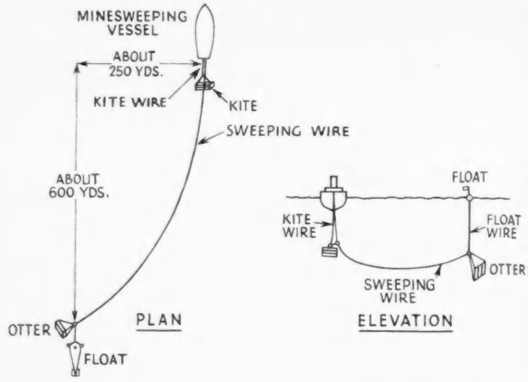


FIG. 22.—Oropesa sweep. The sweeping wire is of serrated hard steel, armed at intervals with static or explosive cutters.

Fig. 25). When its mooring has been severed the mine will float on the surface and may then be sunk by rifle fire.

With about 600 yards of sweep wire paid out, each vessel will sweep a lane about 250 yards wide, but these distances vary considerably with tidal and other conditions. In G formation (Fig. 23) each sweeping vessel steams well inside the swept lane of the preceding sweeper. Dan-buoy layers follow and leave their line of markers some distance within the edge of the swept channel, so that a considerable overlap safety margin is allowed both in sweeping and marking. For checking a channel after sweeping, an "A" sweep is often used by a number of vessels employing only kites and sweep wire (Fig. 26). This type of sweep was used extensively during the 1914-18 war.

The great novel feature of the mining campaign in this war has been the large number of ground mines laid from aircraft; they have also been laid from coastal craft and from the torpedo tubes of submarines. A ground mine is one which rests on the sea-bed until it is fired by the magnetic, acoustic or pressure influence of a passing ship. Since the velocity of detonation is very great and produces immediately a large mass of incandescent gas the explosion on the sea-bed gives rise to an enormous pressure pulse. This travels through the sea at the speed of sound and is the most damaging factor of the explosion. Secondary pulses from the expansion and contraction of the gas bubble as it rises also contribute to the destructive effect, and the force of

FIG. 26.—An "A" sweep, with four minesweepers using kites and sweep wire only. The code letter "A" indicates that this was the earliest type of sweep; it was introduced in the 1914-18 war.

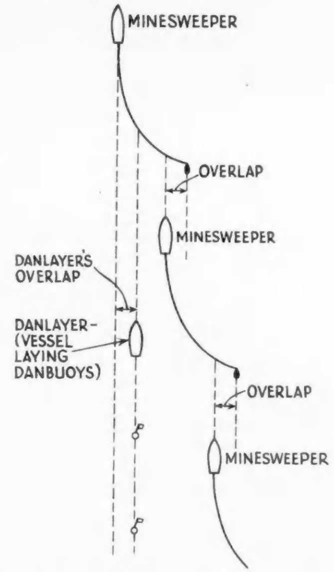


FIG. 23.—Shows how the swept lanes overlap when Oropesa sweeps are used with the minesweepers in G formation.

the rising bubble produces a large "plume" on the surface which is also capable of inflicting damage. The nature of the sea-bed is an important factor: hard sand will give good reflection of the pressure pulse, and, of course, with ground mines the direct and reflected pressure pulses reach the ship simultaneously.

Ground mines generally take the form of long cylinders, as in Fig. 27, and may contain about 600–1000 lbs. of explosive, or even more in a few cases. For high-speed aircraft laying from great heights, retardation by parachute is necessary to prevent breaking up or damage of the components on impact with the water. An air space is left in the nose to adjust the centre of gravity to a suitable position for air- and water-travel. Impact with the water operates an inertia mechanism which detaches the parachute and the mine then travels to the bottom under the influence of its nose, the inclined plane of which tends to bring the mine horizontal and prevents it diving straight into the sea-bed. So that this inclined nose will not interfere with the path in air it is covered at first by a nose fairing which breaks off on impact with the water (see Fig. 27).

When a mine is to be laid from low aircraft at slower speeds its parachute is replaced by a tail consisting of a hollow cylinder of light metal which controls the air path and is released on the impact with the water.

Magnetic Mines

The first ground mines to be laid were those used by the Germans early in the war and designed to fire on the magnetic signature of ships. Any steel which receives blows when in a magnetic field will retain some of the magnetism afterwards; thus ships acquire some permanent magnetism when being built in the earth's magnetic field. During the ship's life this permanent magnetism varies, due to causes such as the firing of guns, collisions and repairing

FIG. 24.—An Oropesa float is lifted clear of the water, after being hauled in at the end of the sweeping operation.

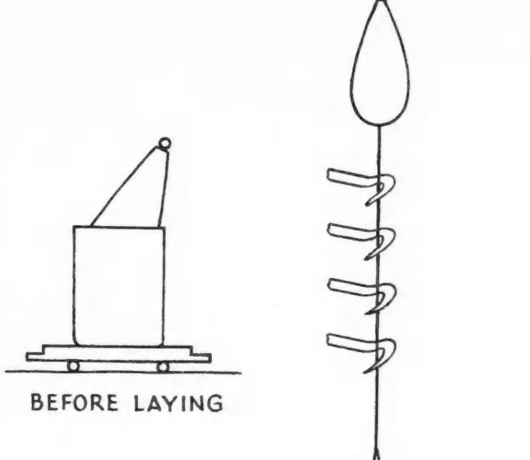


FIG. 25.—Obstructor unit. The float supports a mooring cable armed with cutters, which sever sweep-wires if these drag across the cable.

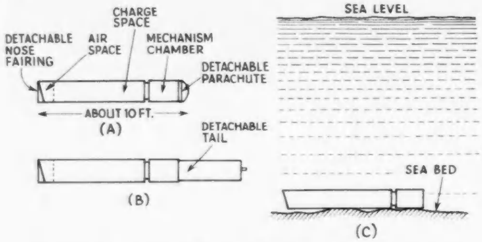


FIG. 27.—The design of ground mines laid by aircraft is varied according to the height from which the mine is dropped. The first type, laid from high-flying planes, come down on a parachute that detaches when the mine hits the water. With the other, for low-level laying, the aerial passage of the mine is controlled by a detachable tail.

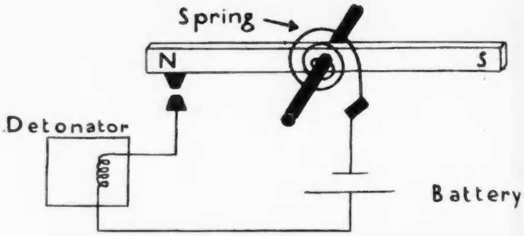


FIG. 29.—The actuation of the German magnetic mine depended upon a dip needle—a small magnet pivoted to rotate in a vertical plane. A helical spring keeps the needle horizontal until a ship passes over the mine, when the intensified magnetic field causes the needle to tip, completing the detonating circuit.

operations. In addition a ship behaves as any large mass of "soft" iron in acquiring induced magnetism when in a magnetic field: this induced magnetism disappears almost entirely when the outside magnetic field is removed. The effect is described as a concentration within the soft iron of the "lines of force" of the magnetic field. A line of force is the direction of the magnetic force acting on a North (seeking) pole at any point in the field. It is convenient to regard the number of lines of force per unit area as a measure of the strength of the field, so that a strong field can be shown by a crowding of the lines. The direction of the earth's field at any point can be shown by pivoting a magnetised needle so that is is free to swing in all directions, i.e. up and down as well as around. In this country such a needle would set in a northerly direction with its North pole pointing downwards at an angle of about 66°; the corresponding lines of force are shown by the three lines on the extreme right of Fig. 28, and their closeness represents the strength of the earth's field. The direction and strength of the magnetic field of the earth varies considerably at different places, e.g. in the southern hemisphere the dip needle will tilt with its South pole downwards, at the Magnetic Equator it will be horizontal and at the Northern Magnetic Pole it will be vertical with its North pole downwards.

The permanent magnetism in ships is only a secondary factor when we consider magnetic mines: the greater effect is the behaviour of the ship as a mass of soft iron in causing a concentration within itself of the earth's magnetic lines of force. This effect is illustrated in Fig. 28 (in which the dotted line is a graph of the ship's magnetic signature at the sea bottom.) Ahead of the ship the lines of force are wider apart than normal, indicating a weakening of the earth's field, and this is illustrated by the negative part of the graph. Under the bows the concentration of lines indicates a strengthened field and the graph correspondingly becomes positive and rises to a maximum. Further aft it falls to normal, then goes below normal, and finally becomes uniformly normal. It will be seen that as we go deeper the lines tend to straighten out again, and the signature is reduced in magnitude.

Our ability to take effective counter-measures to any influence weapon depends on our knowledge of the principle upon which the weapon is based; consequently the recovery and examination of enemy mines was a vital factor during the war. Despite the obvious risks which this work involved, volunteers were never lacking; there has always been the additional danger of booby-traps although this has been reduced by the use of X-ray examination. The magnetic force of the earth's field may be regarded as composed of a horizontal and a vertical component (left of Fig. 28); and the scientists of the Mine Design Department and of H.M.S. *Vernon* found that the first German magnetic mine (dismembered on November 4, 1939) worked on the increase in the *vertical* component of the field under a ship. Their analysis

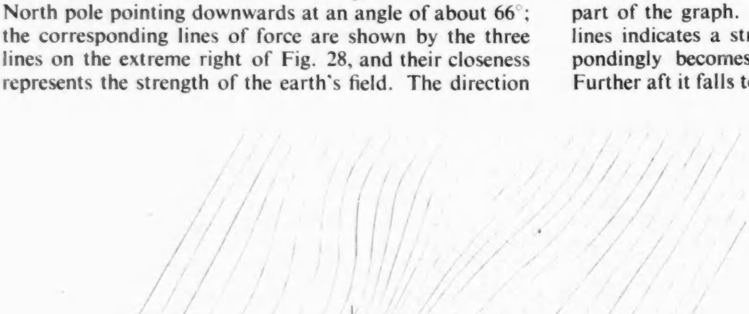


FIG. 28.—The diagram indicates how the "soft iron effect" of a ship sailing in British waters causes a concentration of the earth's magnetic lines of force within the ship. Below is the graph of the ship's magnetic signature at the sea bottom. (*Based on diagram used by Dr. C. F. Goodeve to illustrate his Royal Society of Arts lecture on magnetic mines*).

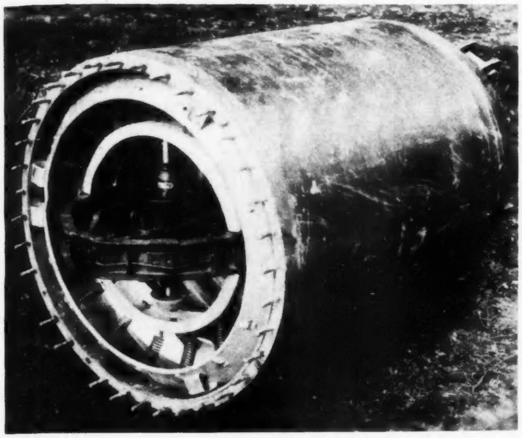


FIG. 30.—The magnetic unit of a German mine, sitting in double gymbal rings in the mechanism chamber at rear end of mine.

showed that a field strength of 50 milligauss was required for firing, and that the mechanism would operate only if the field were applied for several seconds. This latter characteristic had been incorporated in the design to make it more likely that the signature being responded to was that of a ship.

The magnetic mechanism itself was a dip-needle (as in Fig. 29) whose container was positioned inside gymbal rings in the rear of the mine (Fig. 30). The vertical component of the earth's field would make the North pole dip, but soon after the mine was laid a clock caused the helical spring to wind the needle back to the horizontal. After this the mine became "live" and would fire when an increase in the field strength (up to 50 milligauss) overcame the force of the spring and caused the north end to be depressed and make the firing contacts. The method described here provided automatic latitude adjustment, i.e. the magnetic force needed for firing was independent of the strength of the field in which the mine was laid (since the spring balanced out this field), so that the mine could be used anywhere in the northern hemisphere (see also Fig. 31).

Measures were taken to make our ships immune. Firstly, their permanent magnetism was removed by the "flashing", "wiping" or "de-perming" processes. These all involved taking a large electric cable around a ship and passing a heavy current for a short time. By this means the ship was magnetised in a direction opposite to its permanent vertical magnetism which was thus balanced out. But the process had to be repeated every few months since the permanent magnetism gradually returned. The great achievement of this method was immediately before Dunkirk when 400 of our ships were "wiped" in four days.

Secondly, to counteract the induced magnetism, i.e. the "soft" iron effect of Fig. 28, our ships were degaussed. They carried girdles of electric cable through which constantly ran a current creating a magnetic field with "North pole upwards": the current was adjusted so that its magnetic effect just balanced out the previous increase in the earth's field which was thus restored to its normal value.

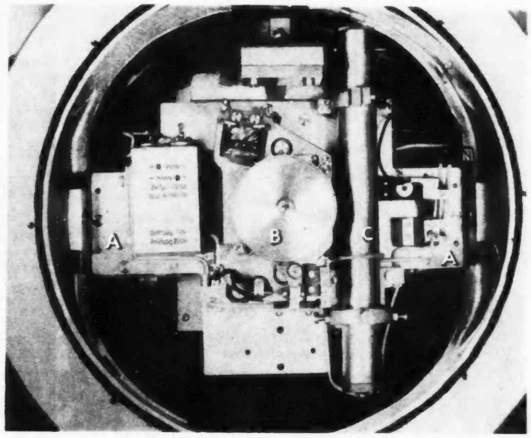


FIG. 31.—Another German magnetic mine unit (of type described in the text). This shows the rectangular box (*AA*), containing the dip needle and hairspring. The clock mechanism (*B*) gives automatic latitude adjustment; the vertical tube (*C*) contains a pendulum mechanism which breaks a circuit when the mine receives a shock—this device prevents the explosion of a single mine detonating a whole minefield.

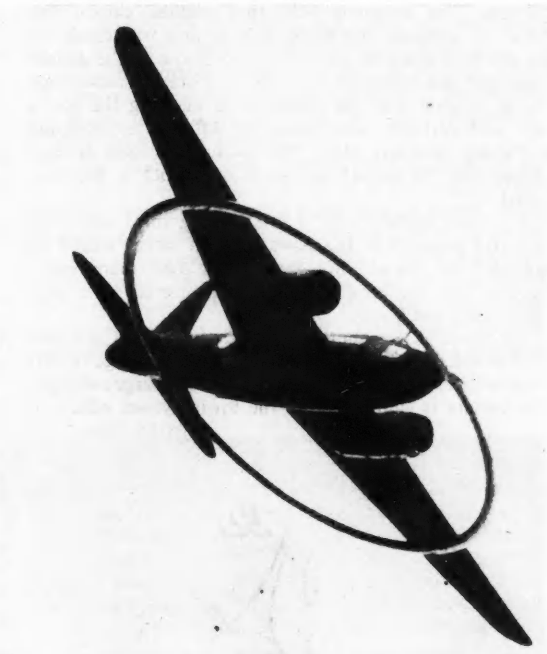


FIG. 32.—Wellingtons of Coastal Command were fitted with large horizontal coils; a heavy electric current passing through these created a magnetic field capable of setting off magnetic mines.

Sweeping by Aircraft

To sweep the mines we had to produce an imitation of the magnetic effect of ships. One method was to use low-flying aircraft fitted with a large horizontal coil underneath

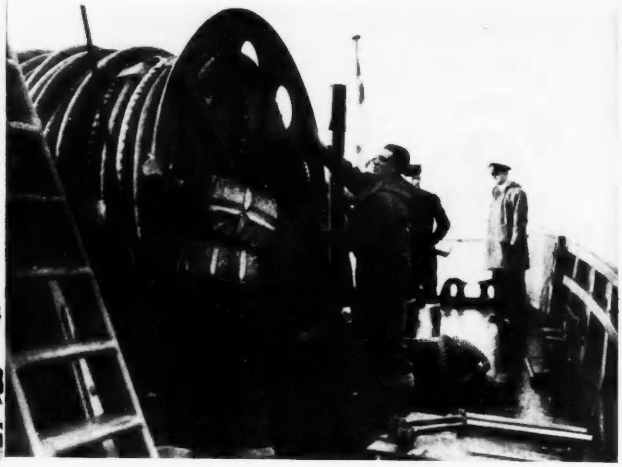


FIG. 33 (*above*)—The giant coil of Double-L cable. FIG. 34 (*left*)—This photograph shows the buoyant Double-L cable being paid out astern of a minesweeper.

(Fig. 32) through which a generator passed heavy electric current. The magnetic field thus created caused the mines to explode, but since their timing was based on the speed of ships the aircraft would be out of the danger area when the explosion took place. A great disadvantage of the method was the difficulty of marking the swept path with certainty, and hence the difficulty of sweeping a channel perfectly clear. We eventually used aircraft sweeps only for special narrow channels such as the Suez Canal.

A second method was to fit sweeping ships with very powerful magnets in the bows, so that mines would be exploded far ahead. But these ships took many nasty knocks, and the crews had to be protected with anti-shock seats and boots.

The towed skid is another magnetic sweep that has been used in special channels. It consists of a flat barge or raft fitted with a platform on which is mounted a large solenoid. The current is supplied from the towing vessel which, of course, is degaussed. The chief disadvantage of the skid was that the coil was expensive to produce, absorbed a large amount of copper, and serious damage or even loss was risked each time a mine was detonated.

A very early form of magnetic sweep was known as the "bosun's nightmare" since it was so difficult to handle: it consisted of an "A" sweep fitted at intervals with 3-ft. or 6-ft. bar magnets and floats, and had some early successes. The suggestion received from one enthusiastic and well-meaning inventor that flat fish should be fitted with bar magnets was not taken up!

The "Double L" was the most successful British magnetic sweep. (Figs 33-36). A degaussed sweeping vessel tows a short tail and a long tail (500 yards) of self-buoyant electric cable. A current of about 2,700 amperes is passed for a few seconds into the sea through an electrode at the end of each cable. The field thus created fires mines over a wide area, but the ship itself is safe, since immediately astern the fields due to the short and long tails cancel each other out. It is found that two ships on parallel courses can sweep, with each surge of current, an area about four times that of a single sweep, due to the overlapping of their fields. In practice, ships are always used in pairs or threes and the effect is as in Fig. 35.

The success of our counter-measures forced the enemy to use further tricks. He guessed that we would occasionally overdo our degaussing: in trying to neutralise the North-pole-down effect in our ships we sometimes made them South-pole-down. So he laid a few South pole mines. These were easy to sweep by reversing the current in the

FIG. 36.—Double-L sweep in action.

Double L, but we had to be more careful with our degaussing. By the autumn of 1940 degaussing ranges were set up at every important port in the country so that the magnetic state of each ship could be automatically recorded when entering or leaving port.

A second measure by the enemy was to increase the sensitivity of his mines, so that they would fire on a field increase of 15 milligauss instead of 50 milligauss. While easier to sweep, these mines again made the task of the degaussers more difficult.

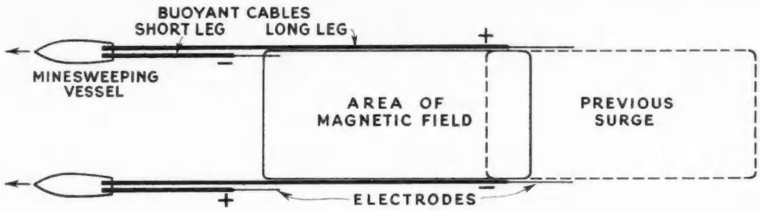


FIG. 35.—The diagram illustrates the use of Double-L sweeps for detonating magnetic mines. At each surge of electric current in the cable, a magnetic field is created in the sea. Sweeping with one vessel is possible, but in practice the ships are used in pairs or threes as the more intense magnetic effect explodes mines over a bigger area.

British magnetic ground mines, first laid in 1940, depend on the *horizontal* component of the earth's field. They contain a long solenoid (C.R. Unit, i.e. Coil and Rod) which extends horizontally through the charge and mechanism spaces. The solenoid has a core of Mu-metal* which causes intense concentration of the earth's field. When a target passes overhead the current induced in the solenoid depends on the rate of change of magnetic field, so that the sensitivity depends on speed of targets. The mine is thus activated by the decrease in field ahead of the ship, and a mechanical delay is incorporated in the firing circuit in order that detonation will not occur until the target is squarely overhead.

To sweep our mines the enemy mainly used the first two of our methods described above, i.e. aircraft sweeps and ships with powerful magnets in the bows. A study of enemy sweeping methods by intelligence and reconnaissance generally leads to the second phase of any mining campaign; i.e. an attack on the sweepers and an attempt to alter mine circuits so that they will discriminate between ships' signatures and the peculiar characteristics of sweeps.

An AA Mine

Consequently we laid some anti-aircraft mines! These were ordinary magnetic mines without a mechanical delay, so that they exploded underneath a sweeping aircraft. And we attacked the enemy sweeping vessels (Sperrbrechers) by laying very coarse (insensitive) magnetic mines which would not be actuated by ordinary targets but only by the very strong field under the Sperrbrechers. In addition, when sweeps were in general use by both sides, the sweeping effort had to be greatly extended to deal with a further device: the period delay mechanism. This simply stopped the mine from firing for the first few times (up to 12) that it was actuated. To counter this the sweepers had to pass over any channel many more times than a ship passed over. Arming clocks which rendered the mine inoperative for several weeks after laying were also an anti-sweeping nuisance.

A further variety which we developed had a circuit requiring two magnetic actuations in opposite directions within a limited period. This, of course, was looking for the trough followed by the hump in the signature of Fig. 28. An aircraft sweep would provide only one actuation which started a clock in the mine. If a second actuation in the opposite direction was not received within a few seconds the clock would switch the circuit back to its original state.

It is almost always necessary to incorporate some anti-counter-mining device in a mine so that it will not be detonated by the explosion of a nearby mine. A single contact magnetic mine might be fired by a shock which altered its magnetic state but the device just described was shock-proof. In their first magnetic mines the Germans used, as an anti-counter-mining device, a pendulum through which the current had to pass making a contact at the bottom; any shock would thus cause the pendulum temporarily to break the circuit (see Fig. 31).

Further study of enemy sweeping methods revealed that an important vessel would often be swept out of a port by a Sperrbrecher proceeding some distance ahead. Some mines were therefore laid incorporating both a coarse and a sensitive magnetic unit in sequence. The Sperrbrecher would provide the strong field for the first actuation. The mine would then "go to sleep" for a time long enough to allow the sweeper to pass. For a few minutes after that the mine could be fired by the ordinary field of a following vessel.

Acoustic Mines

Many of the devices described above were also incorporated at later stages in acoustic mines, after acoustic sweeps had been developed. The detection unit in the German acoustic mine consists of a carbon microphone, the current from which operates a relay. In the corresponding British unit the vibrations of the mineshell itself are picked up by a cantilever, the free end of which normally makes contact with a balanced arm. The pressure wave set up by the engines and propellers of an approaching ship thus vibrate the lever and oscillate the contact arm, causing an electrical circuit to break and make. Normally a small current from a small battery and high resistance is passing through the contacts, but when vibration causes these to "chatter" the current is diverted to feed a condenser in one arm of a Bridge circuit (similar to a Wheatstone Bridge). The build-up of potential across the Bridge continues until the full charging of the condenser operates a relay which fires the mine. It may be seen from this that the vibrator

* Mu-metal is a nickel-copper-iron alloy of the "Permalloy" group which combines a very high magnetic permeability with a low hysteresis.

FIG. 37.—The hammer box for sweeping acoustic mines can be seen on the steel structure on the bows of the vessel. The whole structure rotates around a large hinge, to lower the box into the water. An electrically driven hammer inside the box provides an intense noise which explodes acoustic mines at a great distance.

unit with Bridge is proof against actuation by countermining shock.

For acoustic sweeping we have relied a great deal on the S.A. sweeps which consist of a submerged steel box under the bows containing an electrically driven hammer (see Fig. 37). The intense noise thus produced will actuate acoustic mines some distance ahead. Towed noise-boxes have also been used and the Germans have in addition developed a technique involving large numbers of small explosive charges. As with the magnetic mine, the introduction of the acoustic mine brought a crop of successes. When the development of efficient sweeps brought the initial success to an end both sides turned to devices which either attacked the sweeper, or put an enormous strain on sweeping effort, or distinguished in some way between the characteristics of the sweep and the ship's signature.

The "coarse" acoustic mine is an example of the first type, and the arming clock or period delay mechanism of the second. Both we and the Germans had ingenious examples of the third type. Some of our methods of discrimination depended on the reception of subsonic vibrations which are much more plentiful from ships than from sweeps. These mines, which fired only on receiving a correct quantity of sonic and subsonic vibrations simultaneously, defeated the enemy sweeping methods then in use.

Since both the magnetic and acoustic signatures of ships decrease with depth it is evident that ground mines cannot be laid with useful sensitivities in great depths: nor would this give so great a damage effect against ships. For deeper waters, therefore, acoustic or magnetic detection units are fitted in buoyant mines. This involves some differences in methods, e.g. the C.R. unit is used in a vertical position and specially designed acoustic detectors are employed. Buoyant mines of these types will be designed to take up a depth greater than the contact types, but they will still be subject to sweeping by Oropesa methods.

The German "Sammy" mine was the first which demanded both acoustic and magnetic actuation simultaneously for firing. Later the combinations of these were greatly developed, and the peak of ingenuity was probably reached in 1943-4 by the MX section of the Mine Design Department and H.M.S. *Vernon*. The close co-operation between the scientist designers and naval "users" has throughout been a fine feature in our mining and sweeping organisation. It had been found that any bulk supply system involved inevitable delays, and that standard production methods would often "deliver the goods" only after the situation for which they had been designed had changed. A section of the development staff was therefore switched on to small-scale hand-made production of special circuits designed to attack current enemy tactics. First a special study was made of their sweeping methods and characteristics, and the attack was directed at the sweepers: when intelligence and reconnaissance reports showed the enemy had been forced to change his methods the flexibility of our MX system allowed our next circuits to be designed against his new methods. Later we switched our attack to cover every peculiarity in his convoy methods. Our overlap circuits then gained considerable success in discriminating between ships and sweepers: they depend on the fact that, with a ship, the magnetic and acoustic influences are fairly closely linked together, whereas with a sweeper one is always thrown far ahead of the other. Hence these overlap circuits were designed to function if the magnetic and acoustic effects coincided, but not if either extended too far ahead. Finally the MX production was turned to mines to be used in conjunction with the invasion of Europe.

For pre-invasion mines it was very important to use accurate "sterilising" devices for rendering the mines safe after a predetermined period, so that our own ships could then proceed in safety. The steriliser may either blow up the mine, put a short across its battery, or, in the case of a buoyant mine or obstructor unit, sink it by flooding. Throughout the war it was a constant problem to design sterilisers of sufficient duration and accuracy, yet small enough to be fitted into the very limited surplus space in a mine-shell. Usually a clock which ran with fair accuracy for six months was used. (A little reflection on the number of clocks in a mine will probably explain one of the shortages during the war.)

Another component which gave the designers some trouble was an impact firing switch which would explode the mine like a bomb if it fell ashore, but would leave it to function as a mine if it fell in water. One is reminded of the many parachute-mines (miscalled land-mines) dropped on this country by the Germans in the bombing of London and other large ports and of the supreme confidence in naval counter-measures by a mayor who asked for his Town Hall to be protected by degaussing!

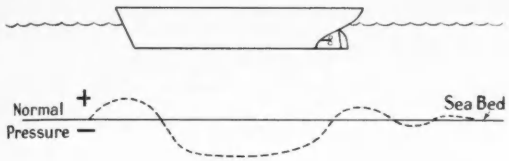


FIG. 38.—The pressure effect under a moving ship. The graph underneath shows how the pressure at the sea bottom varies.

The Pressure Mine

Being dependent on our sea communications we were always much more vulnerable to mining than the enemy was. Consequently it was firm naval policy not to lay any mine which we did not know how to sweep ourselves, since it would be a greater menace to us when the enemy copied it. Thus we knew of an almost unsweepable mine for many years, but held it "up our sleeves" and worked on securing fundamental data that would prove useful in designing counter-measures. Finally, when the Germans used a mine of this type at the critical moment just after D-Day we were ready for it, and it had comparatively little success. This was the pressure mine.

The pressure effects on the bottom caused by a moving ship are quite well-known to canal engineers since these effects cause an inconvenient disturbance of the canal bed. The phenomenon is easy to visualise by analogy with water flowing through constrictions in a pipe. At such a constriction the speed of flow is increased, but the pressure on the walls of the constriction is *reduced*. The principle is used, of course, in the common laboratory water suction pump. Think, too, of the household tap from which water gushes untidily until an anti-splash nozzle is fitted. There is a reduced pressure on the walls of the nozzle since the water then flows in a steady stream, with little tendency to gush outwards. In Fig. 38 the ship is moving from right to left but the motion relative to the water would be the same if we imagine the ship stationary and the water moving from left to right. The water then passes through a "constriction" under the ship and the hydrostatic pressure on the sea-bed there is thus reduced as shown in the dotted signature. On the sea-bed ahead of the ship there is an increased pressure due to water mounting up at the bows, whereas under the ship there is a reduced pressure.

Just as the nozzle effect is more pronounced when the initial rate of flow is large and when the nozzle is small, so the reduction of pressure under a ship is more pronounced when the ship is travelling at high speed and when the distance between her bottom and the sea-bed is small. The magnitude of a ship's suction signature therefore increases with her speed, her draught, and the shallowness of water.

This pressure signature can be detected by simple apparatus and made to operate a ground mine unit. Such a mine is known by the code name "Oyster". The pressure unit of the German "Oyster" mine is shown diagrammatically in Fig. 39, and functions on reduction of pressure. This

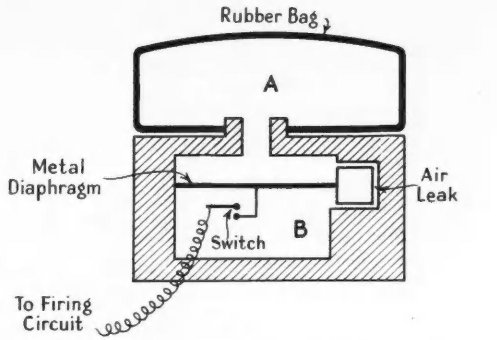


FIG. 39.—The pressure unit of a German "Oyster" mine.

unit is attached to the end of a ground mine and the rubber bag is exposed to the sea, being protected by a metal grid. When the mine is first laid the hydrostatic pressure forces air from the space A to the space B through the air leak. The effect of tide and a slow swell in the sea will also cause air to flow backwards and forwards through the leak. Since these are slow effects air is capable of flowing through the leak at a sufficient rate to keep the pressures equal in A and B. But when a ship passes over the unit the sudden reduction of pressure (about 2 ins. of water) under the ship occurs too rapidly for the flow through the air leak to be able to keep the pressures equal: the suction outside causes the rubber bag to expand, and the metal diaphragm is drawn upwards, thus closing the switch. Arrangements in the electrical circuit require that this switch should be closed for several seconds to complete an actuation; a ship's pressure signature will, of course, do this. Two types of mines were used, one requiring a magnetic and the other an acoustic actuation in addition to the pressure effect for firing.

One of the German "Oyster" mines fell into our hands soon after they were first used and since the basic data had already been prepared the Admiralty was able to make an immediate signal to all ships and authorities concerned advising the safe speeds for every class of ship in various depths of water. Since the effect of swell may affect the sensitivity of the pressure units and occasionally actuate them, swell recording stations were immediately set up over the areas affected, and counter-measures that had been long considered were put in hand. It is not an easy matter to imitate the pressure signature of a ship, since a towed object to do this must be of about the same size as a ship and must be expendable. Fast light craft in formation, however, were of some assistance in providing a wave-making sweep (and the heavy storms just after D-Day also came to our aid). These measures, based on our stored-up knowledge of the principles and data on which these mines would work, led to the enemy reaping poor success even though he was using a new mine in a critical period for us. Seldom has the value of fundamental research been more clearly illustrated than in this case.

Far and Near

The Best Insect Repellent

DURING the war there was a great shortage of phthalate plasticisers needed by the plastics industry, and this developed because dimethyl phthalate, requiring the same intermediates for its manufacture, was finding use in the Middle and Far Eastern theatres of war, where it was proving to be the most effective insect repellent (particularly against the malaria-carrying mosquito) yet available.

Scientific Films

SINCE we started the item called "Science for the Citizen" a great interest among DISCOVERY readers in scientific and technical films has made itself evident; letters to the editor on this topic have been numerous. To meet the demand for information and opinion on such films, we have come to an arrangement with the Scientific Film Association whereby we shall be able to publish each month a review of the outstanding films. The first of these reviews is printed below.

The Technique of Anaesthesia

FILM has been little used for teaching science in the past; caught in the vicious circle of no films—no projectors, both teacher and producer were unable to progress. It seems certain that this impasse was, and to a large extent still is, aggravated by the need for the producer to make a profit on the films he makes. For so long as this condition remains, the producer will tend to make films for which he can anticipate a wide circulation. Such films are not often of much use for classroom teaching.

It is only when films are produced with no intention of making money on them that the circle can be broken. In medicine this has happened sporadically in the past especially in physiology, which has a useful number of simple but valuable teaching films made by the teachers themselves. But recently ICI decided to sponsor a series of films in medicine, and chose anaesthesia as their subject. Since their only aim was to produce the best possible films for medical teaching, no restrictions have hampered production.

The eleven films (produced by the Realist Film Unit and distributed by the Central Film Library, Imperial Institute, London, S.W.7) have been designed to a common plan. Taking each anaesthetic technique in turn, a film shows first the apparatus needed, then normal procedure and results, and lastly abnormal procedures, mishaps and complications. *Open Drop Ether* shows in detail normal induction and stages of anaesthesia, various forms of abnormal induction, and the value of this technique in an emergency. It is a good, clear, straightforward film, one of the best in the series. *Nitrous Oxide/Oxygen/Ether Anaesthesia* discusses in detail the familiar "gas-machine". Largely by diagram the mechanism and working is carefully explained, and then its application to the patient. *The Carbon Dioxide Absorption Technique* is also concerned with the mechanics of special apparatus. Again by animated diagrams the various re-breathing techniques are clearly explained, and the two films together provide an excellent demonstration of the theory and practice of modern gas machines. *Endotracheal Anaesthesia* shows how to prepare an endotracheal tube, the technique of oral intubation under direct vision, "blind" nasal intubation, extubation and the advantages of these procedures. It includes diagrams and direct shots of endoscopic appearances, and a slow-motion sequence of blind intubation. *Intravenous Anaesthesia (Part I)* shows the preparation of pentothal solution and the method of administering it intermittently by syringe for induction or maintenance; precautions needed for this method of anaesthesia are mentioned, and conditions for which it is suitable. *Intravenous Anaesthesia (Part II)* reviews a variety of circumstances and conditions in which pentothal anaesthesia is especially valuable, and gives detailed instructions. *Spinal Anaesthesia* presents the scope, dangers, and technique of spinal anaesthesia using light and heavy impercain. Technique of puncture, and dosage administration for various levels of anaesthesia are detailed, and the distribution of the drug in the spinal canal is ingeniously demonstrated in a glass model. *Respiratory and Cardiac Arrest* is a short film which seeks to explain the factors which cause these upsets and to indicate the measures needed to prevent and remedy them. It is the least clear film in the series. *Handling and Care of the Patient* deals with the care of the patient as an individual rather than a hospital "case". By illustrating wrong and right technique in turn the instruction is pressed home. The last two in the series, *Signs and Stages of Anaesthesia* and *Operative Shock* have just come into circulation.

The medical supervision was entrusted to Drs. Magill and Organe of Westminster Hospital, and the production to The Realist Film Unit. This series represents a landmark in the history of the medical film, for here for the first time a professional film unit and practising doctors associated long enough and closely enough together to get a real insight into each other's viewpoints and problems. (So closely, in fact, did they associate that practically every member of the film unit was anaesthetised for one or other of the films, and many of them can be recognised on the screen.) Not only was liaison close, but the money allocation was such that full professional resources could be used. And the results fully justify this care and expense. Taken as pure cinema they are polished productions which are a pleasure to watch. Taken as medical teaching, they are splendid: sure of their facts, clear, emphatic, sound. They will for a long time be used as the standard against which new medical films are judged.

Adverse criticism, if criticism there must be, is that on small points of detail errors have crept in, sometimes errors of fact inside the series, where one film gives contrary advice to another; sometimes errors of demonstration and errors of omission; sometimes editing is weak, and the wrong impression is conveyed by juxtaposed shots, and sometimes captions should be held longer. Each film has its small mistakes, but it would be difficult to imagine films of this kind which do not, and the overall judgment must be that here is an excellent series of films of which ICI can be proud, and which no progressive teaching school can afford to ignore.—BRIAN STANDFORD, M.R.C.S., D.M.R., F.R.P.S.

> BINDING CASES for Volume VI of DISCOVERY may be obtained from the Empire Press, Norwich, prices 2*s*. 6*d*. A charge of 8*s*. 6*d*. covers the cost of cover and binding. Title page and index are available.

Science for the Citizen

SCIENCE MAGAZINE will be off the air by the time this note is being read. A first-class opportunity for presenting science attractively has been thrown away. It is to be hoped that the Features Department will recognise that certain scientific programmes have been as conspicuously successful as this was unsuccessful. The experience of *Science Magazine* and its abysmally low listener figures should not be allowed to prejudice them against scientific features in general.

Within two months of the programme starting it was apparent that the only motive behind its production was the idea that science was *the fashionable thing*. We regret that the B.B.C. should have been able to inveigle a group of very distinguished scientists to come before the microphone and give a veritable blessing to *Science Magazine* before it had proved its worth. ("Authorities" and "experts" are too often used by Broadcasting House to cover up its inadequacies.) One of those scientists told us a few weeks later that the only hope for *Science Magazine* rested with the radio critics; if they criticised the programme as it deserved, then the producer might perhaps proceed to correct some of the faults and knock the programme into some sort of shape. In the main the critics ignored it—there were more worthwhile programmes to claim their attention. The blame for the failure of *Science Magazine* must be placed squarely where it belongs—on the producer. Quite probably many of the scientists' scripts were not radiogenic, but the producer had no right to expect them to be nor was he entitled to broadcast them without modifying them to meet the special needs of radio presentation. Secondly, he should have made better use of his scientific adviser, who could have directed him towards scientific subjects better suited to radio than some that were chosen.

We do not know whether the scientists

who took part in the first issue of *Science Magazine* have protested at the poor quality of the programme, but in all honesty the B.B.C., which borrowed their authority to give listeners the impression that here was the authentic voice of science speaking at fortnightly intervals, should invite them to a meeting at which the conspicuous failure of *Science Magazine* could be examined and an analysis made of the reasons for that failure. It is too much to expect that the B.B.C. would also allow listeners to hear what scientists thought about the programme's past even though the scientists' views on *Science Magazine's* future were broadcast.

On a Sunday evening that was unmarred by *Science Magazine*, there was a wholly delightful talk by Sir Henry Tizard on Rutherford. One of the "I Knew a Man" series, it was naturally mostly concerned with personal reminiscence, but did make clear to lay listeners what were Rutherford's major scientific contributions. With admirable neatness, Sir Henry grafted on three excerpts from a gramophone record of Rutherford speaking. This talk has now been published—in *The Listener* of December 20.

"Science and Welfare" Conference

A CONFERENCE to discuss "Science and the Welfare of Mankind" will be held in London in February at the Beaver Hall, Garlic Hill, E.C.4. There will be four sessions, of which the first (at 7 p.m. on Friday, February 15) will be introductory and deal with "Science and World Needs" —the background of world affairs and the contribution science can make towards meeting the needs of mankind. The public will be admitted to this session.

The next session will be devoted to "The Implications of Recent Scientific Developments", including the implications of atomic power development: this starts at 2.30 on Saturday afternoon, February 16. The two sessions on Sunday, February 17, starting at 10.30 a.m. and 2.30 p.m., will discuss "The Responsibilities of Scientists in Modern Society" and "The Organisation of Science". The conference, which will be attended by representatives from overseas, is being sponsored by the Association of Scientific Workers in co-operation with other bodies including the Institution of Professional Civil Servants, and the British Association of Chemists.

The Metrovick 50-kV electron microscope.

Exhibition of Scientific Equipment

ONE of the most important exhibitions of its kind to be held for many years will be the N.E. Coast Exhibition of Scientific and Engineering Inspection Equipment, at the Northumberland Road Drill Hall, Newcastle-on-Tyne, on February 12 to 22.

The exhibition, under the auspices of the National Trades Technical Societies, will be open daily from 11 a.m. to 8 p.m. Primarily it is intended for technical people, students, research workers, and operatives, but the general public will be welcomed.

The British electron microscope (with a magnification of 50,000) will be demonstrated. Optical and measuring equipment of the latest types will be shown. Magnetic, fluorescent, and radio-frequency methods of crack detection will be demonstrated: appliances for measuring the thickness of metal coatings, hardness testing, magnetic sorting, spectroscopic methods of analysis and sorting, the electric stroboscope, the introscope, X-ray units, glass thickness viewers and strainometers, and the Braille micrometer are but a few of the exhibits.

America's Scientists Turn Publicists

THE development of the atomic bomb and the social and international implications of the release of atomic energy were discussed at an important conference organised jointly by the American Philosophical Society and National Academy of Sciences at Philadelphia on November 16 and 17. Among the speakers were Dr. H. D. Smyth, author of the best-selling "Smyth Report", Dr. J. R. Oppenheimer (who directed the Los Alamos laboratory), Dr. R. S. Stone, and Dr. Irving Langmuir. The latter set out in cogent fashion his reasons for believing the secret of the bomb should be shared with the Soviet Union. He envisaged the prospect of an atomic bomb armaments race developing in four stages. In the first stage the United States would have the only existing bombs and might produce a sufficient number to wipe out the cities of another power; in stage two, one or more other nations would have some bombs but not enough to wipe out all U.S. cities, so an attack by the U.S.A. would encounter retaliation by atomic weapons. The third stage would be reached when the other nations would have sufficient stockpiles of atomic bombs to wipe out all U.S. cities. If the arms race continued there would be a fourth stage: one nation, possibly not the U.S.A., would have enough bombs to destroy another nation by surprise attack so completely that no retaliation would be possible. Dr. Langmuir explained why he thought Russia might reach the fourth stage before the U.S.A. If she was not reassured by a world agreement for the control of atomic

Dr. Henry DeWolf Smyth, the American physicist and Princeton professor, who wrote the U.S. War Department's report on the atomic bomb—the "Smyth Report" —that became the scientific best-seller of 1945. His Ph.D. was gained in England, for research work at Cambridge University, in 1923.

power, Russia might be willing, unlike the U.S.A., to forgo improvement in living standards and embark on a 5-10 year plan for the development of atomic power. He suggested Russia might be prepared to devote as much as 10 per cent of the national income to such work as compared with the fraction of one per cent of the national income devoted by America to research before the war.

A Federation of Atomic Scientists was recently set up in America, to provide a link between the several groups of atomic scientists which came into being in 1945. First of the groups to be established was the Association of Los Alamos Scientists; its original membership was 450, and included Army N.C.O.s and W.A.C.s working on the atomic bomb project. Their lead was followed elsewhere and the following bodies were formed: the Association of Manhattan Project Scientists, Atomic Scientists of Chicago, Association of Oak Ridge Scientists, Atomic Engineers of Oak Ridge, Atomic Production Scientists (also at Oak Ridge, where the largest plant was operated), and the Association of Cambridge Scientists. At a November meeting representatives of all these groups made it clear that they considered their first duty to be towards the public, who needed information about all implications of atomic energy.

All these groups have been applying their energy to advising publicists of the press and radio as well as arranging for public lectures by atomic-bomb scientists, and approaches have been made to senators and congressmen. One result had been that scientists' letters to congressmen had found their way into the Congressional Record, while evidence had been given by many of the scientists before Senate committees. Their efforts had evidently been undertaken in the spirit that actuated Dr. Smyth in the summary to his report to write: *it is a semi-technical report which it is hoped men of science in this country can use to help their fellow-citizens in reaching wise decisions; the people of the country must be informed if they are to discharge their responsibilities wisely.* The American scientists, however, recognise the Smyth Report as only the

first stage in the biggest campaign of scientific publicity that they have yet had to organise. They are indeed saying that the Smyth Report is too technical for the layman, and are invoking the aid of publicists in all fields, including the Church, to help them. Up till now films have been of little assistance in the campaign, but an approach has been made to Walt Disney with the proposal that his studios should make a film on the lines of *Victory through Air Power* to impress upon the public what would be the effects of atomic war.

Obituary

THE death occurred on December 15 of DR. E. F. ARMSTRONG, F.R.S. Son of a famous father (Professor H. E. Armstrong, who was professor of chemistry at the Imperial College of Science and Technology), he was early attracted to a scientific career and had the added advantage of being early introduced to science at St. Dunstan's College, Catford, a school that pioneered scientific teaching; one of his fellow-students was Professor Andrade. For his researches on carbohydrates and enzymes, he was elected F.R.S. in 1920.

Much of his life was spent on chemical consultant work, and he came to be connected with many firms in the chemical industry. He was president of the Society of Chemical Industry in 1922-24, and chairman of the Association of British Chemical Manufacturers in 1930-33. He was twice chosen as chairman of the British Standards Institution. In 1926 he was chairman of the British Association of Chemists. At the time of his death he was president of the Royal Society of Arts.

He was also associated with the gas industry, on which he wrote an article for DISCOVERY just over two years ago.

During the second World War he rendered valuable service to the Ministry of Home Security as chemical adviser. Some months ago he transferred to the Ministry of Works, and became concerned with scientific problems in housing; he was to have delivered an address on this subject in the last conference of the British Association but the illness which proved fatal a week later prevented his attendance.

When the Conference of Allied Ministers of Education came into being in 1942 he took a very active part in connection with scientific educational matters that came within its province, and he presided over the affairs of the Conference's Science Commission set up in July 1943. One of the post-war problems to which he devoted a great deal of personal interest was the question of rehabilitating the wrecked laboratories of Europe, which the Science Commission investigated in detail, to arrive at an estimate of £100,000,000 for the cost of making good the destruction wrought by the war. Dr. Armstrong realised that very material considerations would be limiting factors in any attempt to give practical effect to the ideas of the Science Commission, and he did not hesitate to direct attention to a fundamental aspect

The late Dr. E. F. Armstrong.

of rehabilitation—the supply of scientific instruments to continental laboratories. He took the line that Britain would have to manufacture much of the apparatus required, and he was disappointed at the way this eminently sensible suggestion was received in official circles. Never one to suffer fools (particularly bureaucratic fools) gladly, he used to tell his friends of the Government official who reprimanded him for "acting like a commercial traveller for the British scientific instrument manufacturers". To which Dr. Armstrong's reply had been, "Well, my opposite number from the other side of the Atlantic happens to be connected with a scientific instrument firm."

UNRRA Fellowships for Technicians

UNRRA is to provide fellowships for further technical training for experts from the war-shattered countries of the world. These fellowships will be available to technicians from all the countries where UNRRA is now working. They will provide, at UNRRA's expense, further training in those spheres of work closely allied to the basic programmes of relief and rehabilitation, such as health, welfare and agriculture. In selecting candidates for the fellowships, every attempt will be made to choose those who will give assurance of returning to their own countries to carry on their work.

1300 Government Physicists

IN the House of Commons last month it was stated that there are, outside the Post Office, upwards of 9000 qualified engineers and over 1300 physicists in government service.

THE COVER PICTURE.—This photograph was taken at the Canadian Army's "khaki university" at Leavesden, near Watford. The two students are H. E. Laycock, who saw five years' service with the Royal Canadian Artillery and is studying medicine, and Nursing Sister D. Johnson, who is working for a degree.

JUNIOR SCIENCE Seeing Small Things

HERE is a simple experiment for you to try for yourself. Take an umbrella (the fabric should be of silk—any piece of fine silk, in fact, will do for this experiment) and look through it at the headlamp of a distant car. The result is rather astonishing. Instead of seeing one single spot of light you will observe a pretty and regular pattern of light spots which are divided from each other by dark lines.

The reason for this phenomenon is the wave nature of the light rays. The silk fabric provides a pattern of tiny holes rather like a very fine sieve and the light rays striking the edges of these holes "bend" a little around the edges. Thus from any of these holes there issues not just a straight beam of light but a cone which widens as one goes farther away from the umbrella. Some distance behind the silk threads the cones of light coming from neighbouring holes meet and this is how the pattern which you see is created. Wherever the crests of two light waves coming from different holes meet, they form another crest, and the same sort of thing happens when two troughs meet. However, there are also places where the crests from one hole meet the troughs from the neighbouring hole and then they cancel out. Thus in these places there are neither crests nor troughs; that means the effect of the two "interfering" cones will be the same as if there were no light waves at all. In other words, the bright spots of the pattern you see are the regions where crest meets crest and trough meets trough, while the dark lines mark the places where crests and troughs coincide.

The phenomenon happens only because the light waves do not travel in dead straight lines but bend a little around the edges of obstacles. We are, of course, quite familiar with the fact that waves bend around things. The waves of sound, for instance, can be heard even if we cannot see their source. If somebody calls you from behind a wall you can hear him, because the sound waves bend over the wall. It is true that you cannot hear as well as if the wall were not there but nevertheless the wall will not throw a shadow of sound as it throws a sharp shadow of light. The reason for this is that the light waves are very much shorter than the waves of sound.

Naturally, the light waves, too, bend a little over the wall but this effect is so slight that we do not notice it in comparison with the size of the wall. The situation is, however, very different when very small objects are concerned. As we have just seen, light waves bend noticeably round a thin thread and this means that its shadow will become blurred, and very small things which are of about the same size as the wavelength of light—$\frac{2}{100000}$ inch—will give no shadow at all because the light waves bend round them as sound waves bend round a lamp post. Thus very tiny things are invisible, even under the most powerful microscope. K.M.

Printed and published in Great Britain by Jarrold & Sons, Ltd., The Empire Press, Norwich.

be connected
firm."

chnicians

llowships for
r experts from
of the world.
available to
untries where
. They will
pense, further
work closely
mes of relief
ealth, welfare
ng candidates
attempt will
who will give
o their own
rk.

last month it
outside the
000 qualified
physicists in

photograph
dian Army's
vesden, near
s are H. E.
service with
llery and is
ursing Sister
for a degree.

S

trough meets
ark the places
ncide.
only because
vel in dead
e around the
e, of course,
that waves
ves of sound,
en if we can-
mebody calls
ou can hear
es bend over
cannot hear
ot there but
not throw a
throws a
e reason for
e very much
und.
too, bend a
effect is so
in compari-
. The situa-
nt when very
As we have
d noticeably
s means that
ed, and very
out the same
ght— $\frac{2}{100000}$
t all because
em as sound
. Thus very
n under the
K.M.